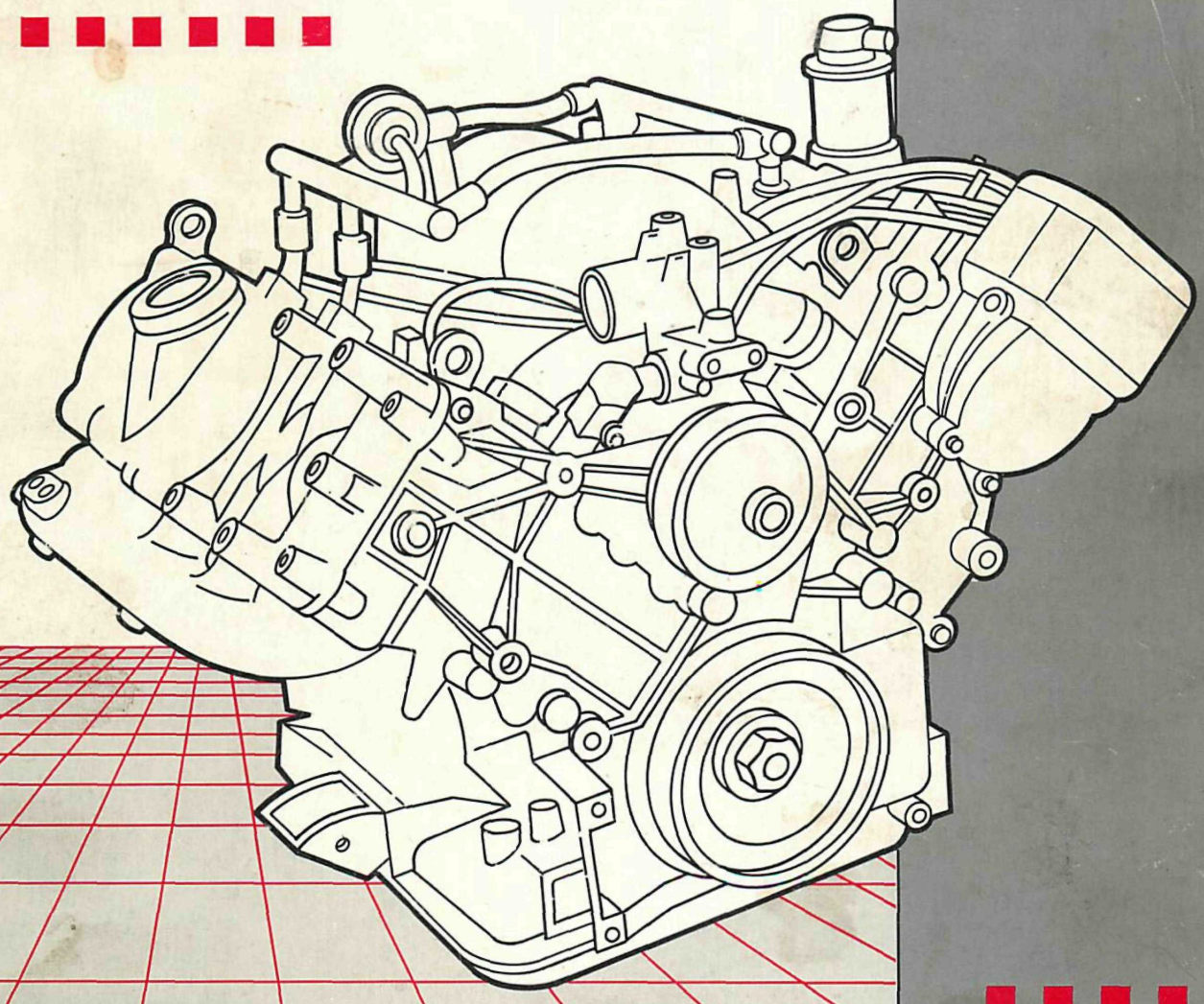
PREMIER/ MONACO

3.0 liter



ENGINE OVERHAUL

Student Reference Book

SERVICE TRAINING

SAFETY NOTICE

CAUTION

ALL SERVICE AND REBUILDING INSTRUCTIONS CONTAINED HEREIN ARE APPLICABLE TO, AND FOR THE CONVENIENCE OF, THE AUTOMOTIVE TRADE ONLY. All test and repair procedures on components or assemblies in non-automotive applications should be repaired in accordance with instructions supplied by the manufacturer of the total product.

Proper service and repair is important to the safe, reliable, operation of all motor vehicles. The service procedures recommended and described in this publication were developed for the professional service personnel and are effective methods for performing vehicle repair. Following these procedures will help assure efficient economical vehicle performance and service reliability. Some of these service procedures require the use of special tools designed for specific procedures. These special tools should be used when recommended throughout this publication.

Special attention should be exercised when working with spring or tension loaded fasteners and devices such as E-Clips, Circlips, Snap rings, etc., as careless removal may cause personal injury. Always wear safety goggles whenever working on vehicles or vehicle components.

It is important to note that this publication contains various **Cautions** and **Warnings.** These should be carefully read in order to minimize risk of personal injury, or the possibility that improper service methods may damage the vehicle or render it unsafe. It is important to note that these **Cautions** and **Warnings** cover only the situations and procedures Chrysler Motors has encountered and recommended. Chrysler Motors could not possibly know, evaluate, and advise the service trade of all conceivable ways that service may be performed, or of the possible hazards of each. Consequently, Chrysler Motors has not undertaken any such broad service review. Accordingly, anyone who uses a service procedure, or tool, that is not recommended in this publication, must assure oneself thoroughly that neither personal safety, nor vehicle safety, be jeopardized by the service methods they select.

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SERVICE

MASTER TECH

FOREWORD

This book contains information on the 3.0 liter PRV Engine used in 1988 - 1990 Eagle Premier Models and 1990 Dodge Monaco Models.

The Engine Overhaul Procedures, contained in this book, are written for an engine that has been removed from the vehicle for repair; However, some of the procedures can be adapted for repairs while the engine is still in the vehicle (other "In Vehicle" repair procedures are covered in the Eagle Premier or Dodge Monaco Service Manual).

Please adhere to the "Cautions" and "Warnings" in this book to prevent any accidents that may cause personal injury as well as damage to the engine components being serviced.

All information, illustrations, and specifications contained in this book are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.

Chrysler Motors reserves the right to make improvements in design or to change specifications to these systems without incurring any obligation upon itself.

TABLE OF CONTENTS

GENERAL SPECIFICATIONS

VEHICLE TYPE	BB BODY, Eagle Premier, Dodge Monaco
ENGINE TYPE	Z7X
ENGINE SUFFIX	711
ENGINE DISPLACEMENT	3.0L,180 CU. IN. (2975 cc)
CYLINDER BORE	3.66 in., (93mm)
STROKE LENGTH	2.87 in., (73mm)
COMPRESSION RATIO	9.3 to 1
HORSE POWER	150 HP @ 5000 RPM
TORQUE	171 FT-LBS @ 3750 RPM

ENGINE IDENTIFICATION CODE

The 3.0L V-6 engine identification tag is attached to the right-hand side of the cylinder block, below the exhaust manifold.

The first six digits (A) - Z7X711 - identifies the engine type.

The 2nd row of digits (B) identifies the numerical sequence of engine build.

NOTE: *Vehicles built for Tennessee have an additional number stamped behind the right-hand side engine mount bracket. The number used is the final line building sequence number followed by the last two digits of the model year. The number starts and ends in an asterisk(*) to prevent alteration - *1192788*).*

OIL PRESSURE/CAPACITY SPECIFICATIONS

Oil Pressure:

At Idle Speed (790 Rpm)	14.7 PSI (1 Bar) gauged
At 5500 Rpm	60 PSI (4 Bars) gauged

Note: *Check oil pressure only when the thermostat is open and the engine coolant temperature is at 192° F. (89° C.)*

Oil Capacity:

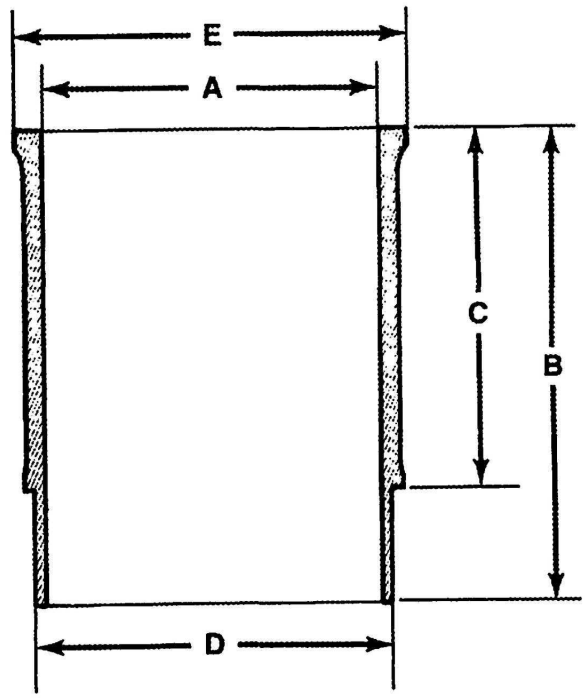
With filter change	6.0 quarts (5.7 Liters)

DIMENSIONAL SPECIFICATIONS

	USA (Inches)	METRIC
CAMSHAFT		
End Play	0.003-0.011	0.07-0.14mm
Intake Valve		
Open	14° BTDC (Before Top Dead Center)	
Closes	58° ABDC (After Bottom Dead Center)	
Exhaust Valve		
Open	56° BBDC (Before Bottom Dead Center)	
Closes	12° ATDC (After Top Dead Center)	
Valve Overlap	26°	
Intake Duration	252°	
Exhaust Duration	248°	
CONNECTING RODS		
Length (Small End to Large End Centerline)	5.75	146.15mm
Piston Pin Bore Diameter	0.9826-0.9831	24.959-24.971mm
Connecting Rod bearing Bore (Without Bearings)	2.508	63.704mm
Side Clearance	0.008-.015	0.20-.038mm
Maximum Twist	0.002	0.075mm
Maximum Parallel (Bend)	0.003	0.080mm
Weight	26.545-26.721 oz	752.5-757.5 g.
CRANKSHAFT		
End Play	0.003-0.010	0.07-0.27mm
Main Bearing Journal Diameter	2.7576-2.7583	70.043-70.062mm
Main Bearing Clearance	0.0015-0.0035	0.038-0.089mm
Connecting Rod Journal Diameter	2.3611-2.3618	59.971-59.990mm
Main Bearing Bore in block	2.9134-2.9141	74.000-74.019mm
CYLINDER BLOCK		
Liner Protrusion (prior to # 89616)	0.0051-0.0078	0.13-0.20mm
(Starting with # 89616)	0.0019-0.0047	0.05-0.12mm
CYLINDER HEAD		
Combustion Chamber Volume	3.09 cu.in.	50.6 cc
Valve Guide Inside Diameter	0.315	8mm
valve Guide Outside Diameter	0.512	13mm
Repair Valve Guide Outside Diameter	.526	13.35mm
Valve Guide Length		
Intake	1.772	45mm
Exhaust	1.929	49mm
Valve Seat Angle		
Intake	45°	
Exhaust	45°	
Flatness (Max. Warpage) (NOT RESURFACEABLE)	0.002	0.051mm
Head Gasket Thickness (all engines prior to #89616)	0.067	1.70mm

(Engines built starting with #89616)	0.057	1.45mm
Cylinder Head Height	4.363	110.83mm
PISTONS		
Compression Height (Pin Bore Centerline to Piston Top)	1.524	38.7mm
Piston Ring End Gap (Clearance)		
#1 Compression Ring	0.016-0.022	0.40-0.55mm
#2 Compression Ring	0.016-0.022	0.40-0.55mm
Oil Control Ring	N/A-- Segmented Ring	
Piston Ring Side Clearance		
#1 Compression Ring	0.001-0.002	0.03-0.05mm
#2 Compression Ring	0.001-0.002	0.03-0.05mm
Oil Control Ring	0.0015-0.0035	0.04-0.09mm
Piston Ring Thickness		
#1 Compression Ring	0.069	1.75mm
#2 Compression Ring	0.069	1.75mm
Oil Control Ring	0.135-0.137	3.44-3.47mm
Piston Ring Groove Height		
#1 Compression Ring	0.070-0.071	1.78-1.80mm
#2 Compression Ring	0.070-0.071	1.78-1.80mm
Oil Control Ring	0.138-0.139	3.51-3.53mm
Piston Ring Groove Diameter (inside)		
#1 Compression Ring	3.319-3.327	84.30-84.50mm
#2 Compression Ring	3.295-3.303	83.70-83.90mm
Oil Control Ring	3.260-3.268	82.80-8300mm
Piston Pin Bore Diameter	0.9844-0.9848	25.004-25.013mm
Piston Pin Diameter	0.9839-0.9843	24.991-25000mm
Piston Pin to Bore Clearance	0.0015-0.0085	0.004-0.022mm
Piston Pin I.D.	0.591	15mm
Piston Pin Length	2.598	66mm
ROCKER ARM		
Rocker Arm Diameter	0.786-0.787	19.959-19.976mm
VALVES		
Valve Length		
Intake Valve	4.427	112.45mm
Exhaust Valve	4.388	111.45mm
Valve Stem Diameter	0.315	8mm
Valve Head Diameter		
Intake Valve	1.783	45.3mm
Exhaust Valve	1.516	38.5mm
Valve Face Angle	45°	
Valve Face Width		
Intake Valve	0.057-0.087	1.45-2.21mm
Exhaust Valve	0.063-0.104	1.6-2.64mm
Valve Margin		
Intake Valve	0.059	1.50mm
Exhaust Valve	0.067	1.70mm

VALVE SPRINGS		
Free Length	1.909	48.5mm
Spring Tension		
Valve Closed	76 lb. @ 1.575	337N @ 40mm
Valve Open	155lb. @ 1.220	691N @ 31
CYLINDER LINER		
Liner Inside Diameter (A)		
3 classes of liners identified by		
Notches on top of liner.		
1 Notch	3.6614-3.6618	93.00-93.01mm
2 Notches	3.6618-3.6622	93.01-93.02mm
3 Notches	3.6622-3.6626	93.02-93.03mm
Liner Total Length (B)	5.16	131.10mm
Liner Length (C) Top to		
Block Seat		
(Engines Built prior to #89616)	3.90	99.055mm
(Engines Built starting with		
# 89616)	3.897	98.975mm
Liner Outside Diameter (D)	3.85	97.68mm
Liner Outside Diameter (E)	4.22	107.2mm
CYLINDER LINER SEAL		
Liner Seal Thickness (Identified		
by **Color** on the seal)		
RED Color Code	0.004	0.10mm
SILVER Color Code	0.005	0.12mm
BLUE Color Code	0.006	0.15mm

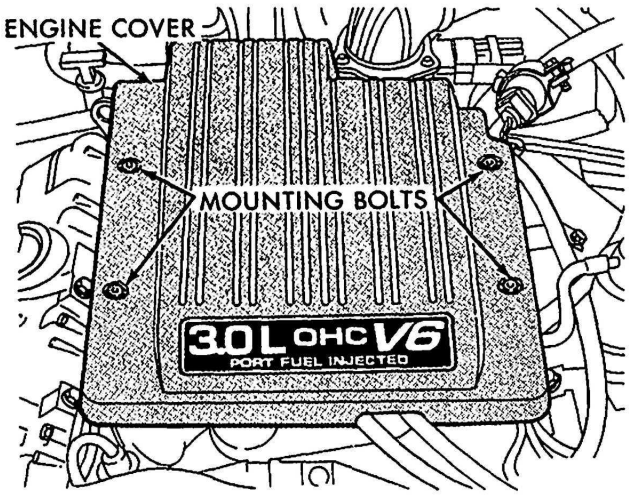


ENGINE DISASSEMBLY

ENGINE COVER

The engine Intake Manifold is covered by an engine cover which is attached to the fuel rail.

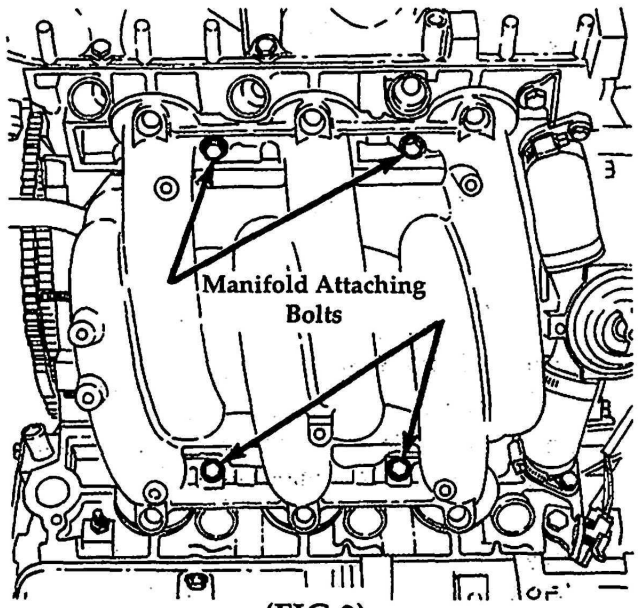
- Remove mounting screws, and remove the engine cover . (FIG. 1)



(FIG. 1)

INTAKE MANIFOLD

The intake manifold is attached to the cylinder heads by four bolts. O-rings located in a groove around the intake port in the cylinder heads seal the two mating surfaces. (FIG. 2)

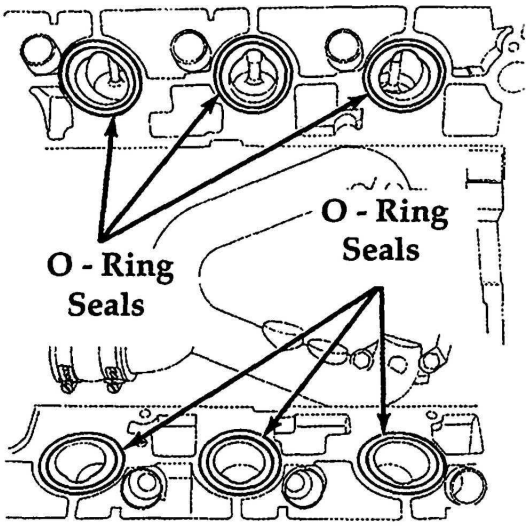


(FIG.2)

NOTE: *The O-rings MUST be replaced whenever the intake manifold is removed.*

Removal

- Remove the manifold attaching bolts, lift the manifold up and away from the engine.
- Remove the O-ring seals. (FIG.3)

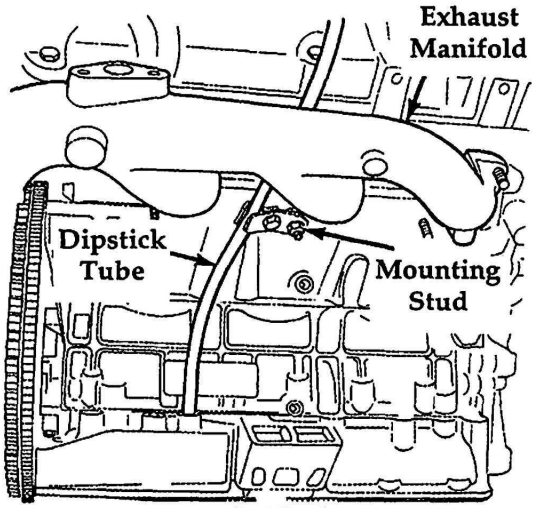


(FIG.3)

EXHAUST MANIFOLDS

Removal Right side

- Remove the nut holding the dipstick tube to the exhaust manifold mounting stud.
- Gently twist and pull up on the dipstick tube until it comes out of the lower casing.
- Remove exhaust manifold mounting nuts.
- Remove the exhaust manifold. (FIG.4)

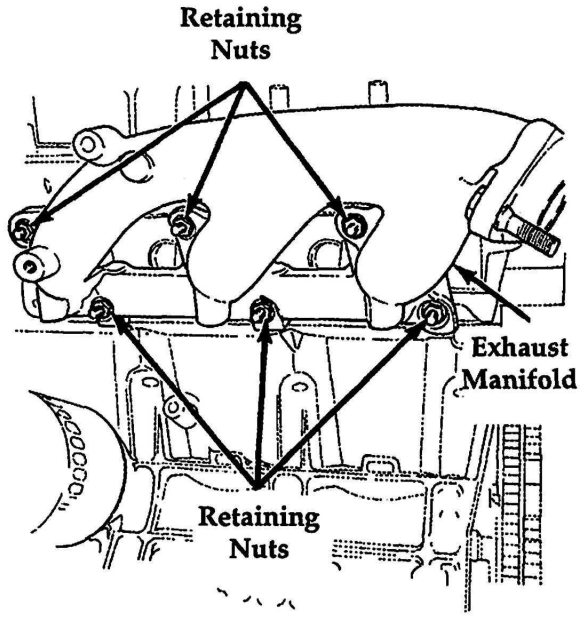


(FIG.4)

- Remove the old gaskets.
- Clean the carbon from the manifold mounting surfaces.

Removal Left side

- Remove Exhaust Manifold mounting nuts.
- Remove exhaust manifold . (FIG. 5)
- Remove old gaskets.
- Clean carbon from the manifold mounting surfaces.

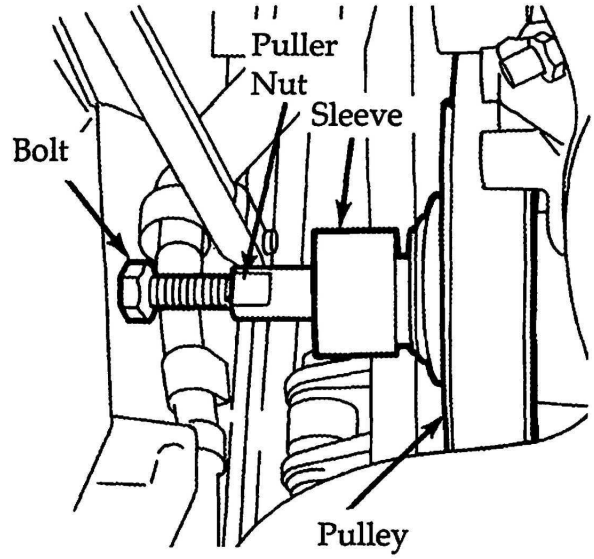


(FIG. 5)

Water Pump Pulley

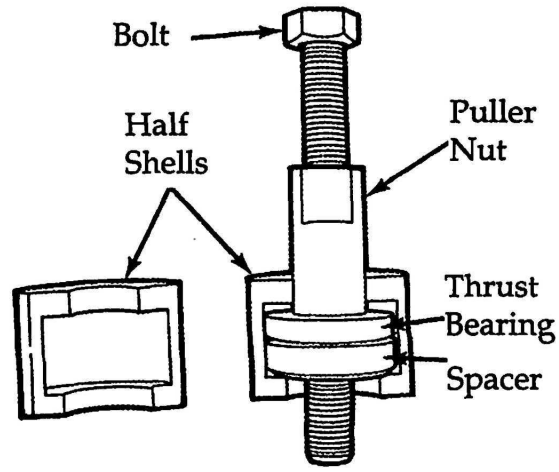
Removal

- Install puller tool # 6160 with thrust bearing between the puller nut at water pump pulley. Turn bolt in until it stops and then back it off one complete turn.
- Install half shells. (FIG.6 & 7)



(FIG. 6)

- Install sleeve over half shells.
- Back puller nut off to remove pulley.

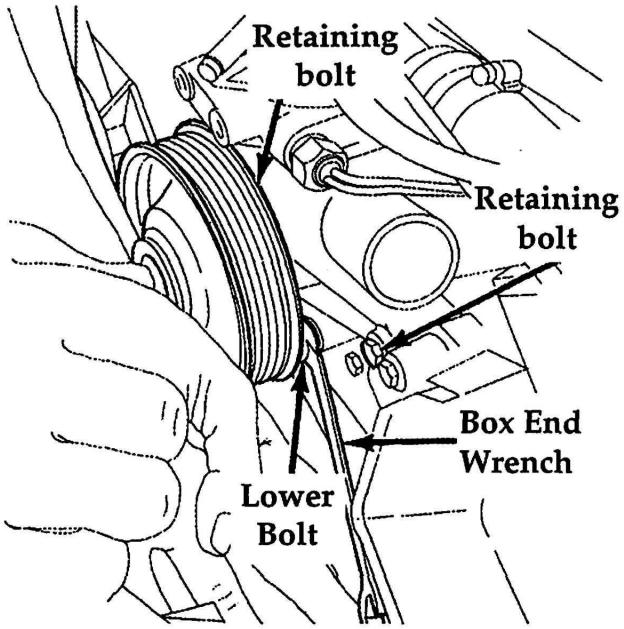


(FIG.7)

WATER PUMP

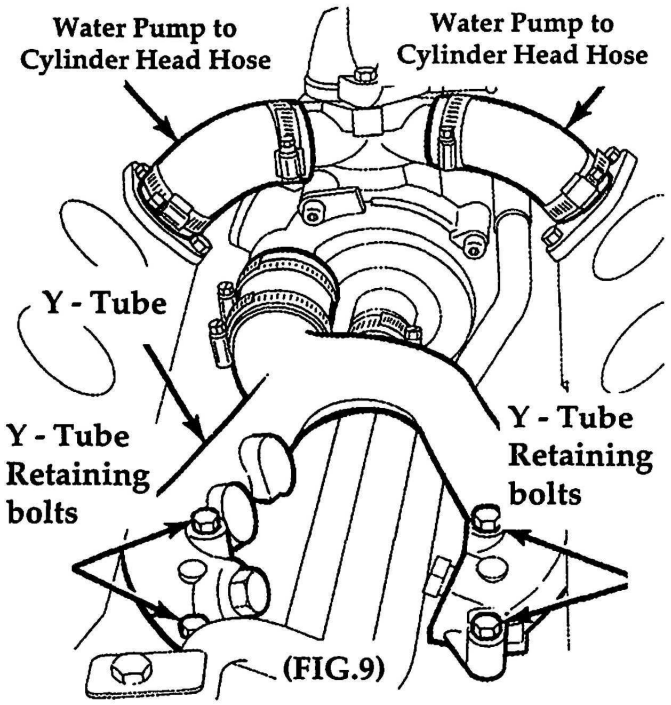
Removal

- Remove water pump retaining bolts. (FIG.8)
- Use a box end wrench to remove lower bolt.



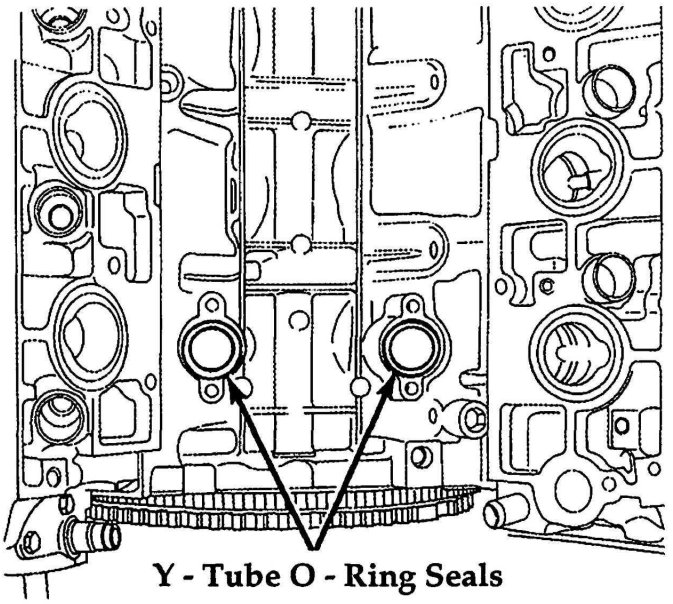
(FIG. 8)

- Disconnect hoses at the cylinder heads.
- Remove "Y" tube to cylinder block mounting bolts. (FIG. 9)



- Remove the water pump and "Y" tube as an assembly.
- Remove "Y" tube O-ring seals from the cylinder block and discard them. (FIG.10)

NOTE: *Never reuse the O-ring seals.*



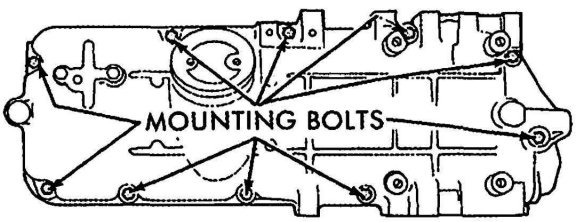
(FIG.10)

CYLINDER HEAD COVERS

NOTE: *The right and left hand cylinder head covers and cylinder head cover gaskets are not interchangeable.*

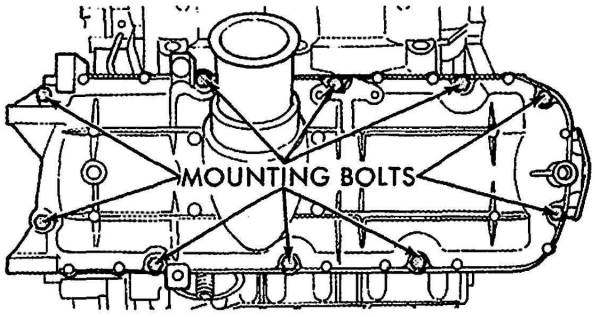
Removal

- Remove the cover mounting bolts from the right and left sides. (FIG. 11 & 12)
- Remove the covers and gaskets.
- Discard the gaskets.



RIGHT SIDE

(FIG. 11)



LEFT SIDE

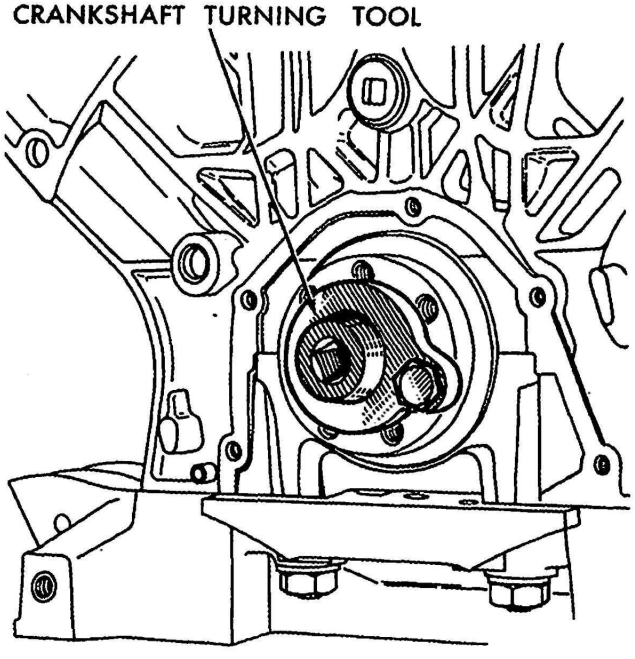
(FIG. 12)

NOTE: *Do not reuse the gaskets.*

CRANKSHAFT PULLEY

Removal

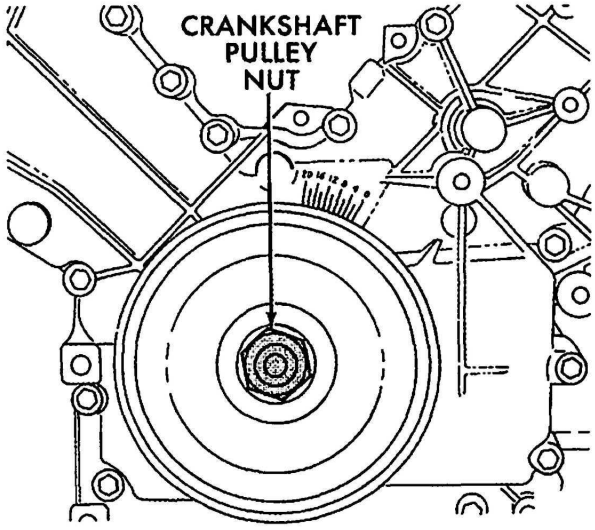
- With the rear main seal housing removed, install crankshaft turning tool #6072 at the flywheel end of the crankshaft. (FIG. 13)
- A thread lock is applied to the crankshaft pulley nut. Use a BRASS hammer and strike the nut prior to loosening. Remove the pulley nut. (FIG 14)



(FIG. 13)

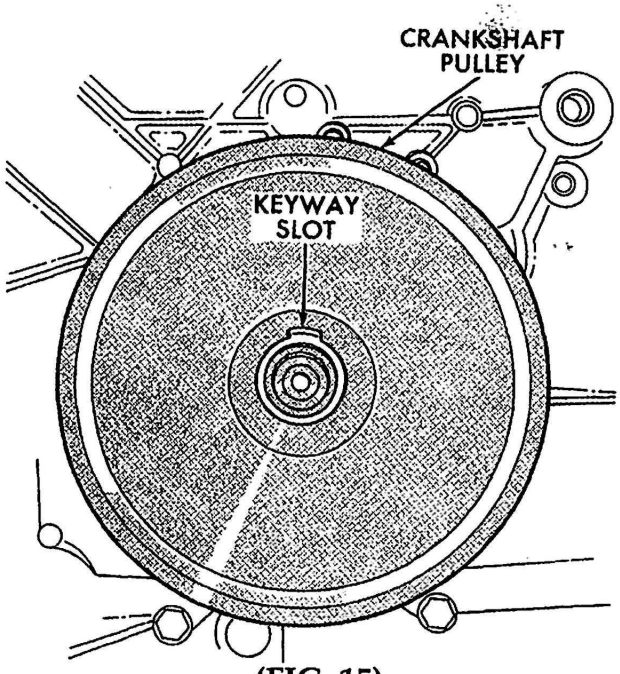
CAUTION: *Do not use an air impact gun to remove the crankshaft nut.*

NOTE: When removing the crankshaft pulley, first remove the nut and then determine the position of the keyway slot. The keyway slot must point straight up before removing the crankshaft pulley. The key ould fall out of the crankshaft if the pulley is removed with the keyway facing down.



(FIG.14)

- Check the position of the keyway slot. If it does not point up, turn the crankshaft until it does. (FIG. 15)



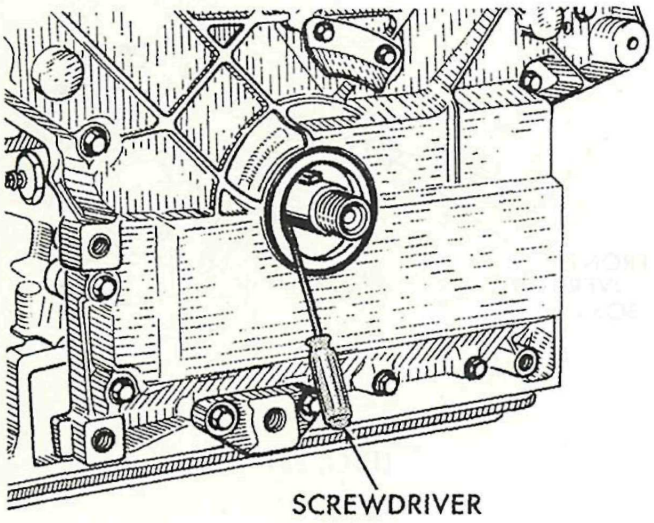
(FIG. 15)

FRONT CRANKSHAFT OIL SEAL

Replacement

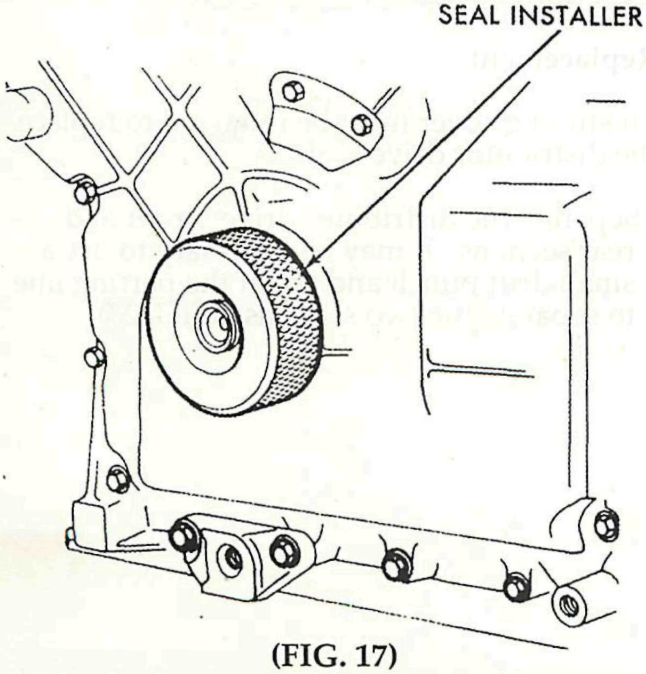
- If the front cover is off of the engine, use a socket to push the old seal out of the cover.

- If the cover is attached to the engine, use a screwdriver and carefully pry the seal out of the cover taking care not to damage the seal locating bore. (FIG. 16)



(FIG. 16)

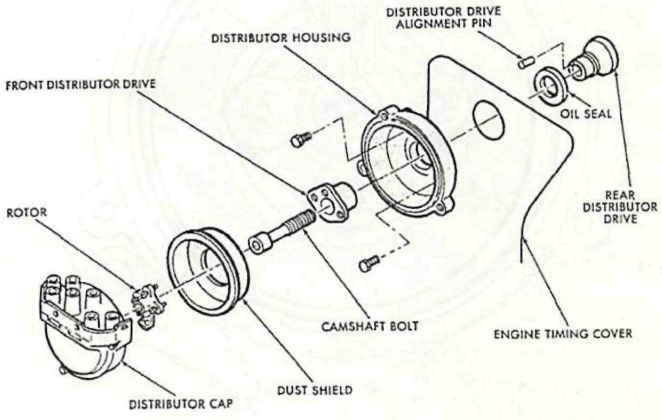
- Lightly oil the new seal and install it using seal installer tool, number 6077. (FIG. 17)



(FIG. 17)

DISTRIBUTOR CAP/ROTOR/DUST COVER

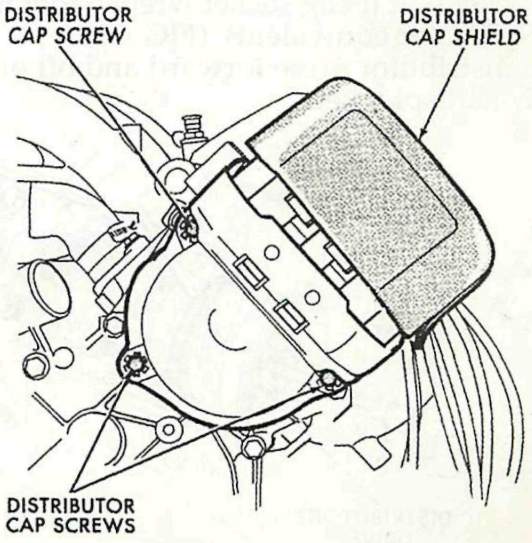
The distributor rotor is attached to the front of the distributor drive which is indexed to the left camshaft. The distributor drive itself is a two piece assembly that is pinned together. The drive rides in an oil seal located in the engine timing cover behind the distributor housing. The engine timing cover must be removed to service the oil seal. (FIG. 18)



(FIG. 18)

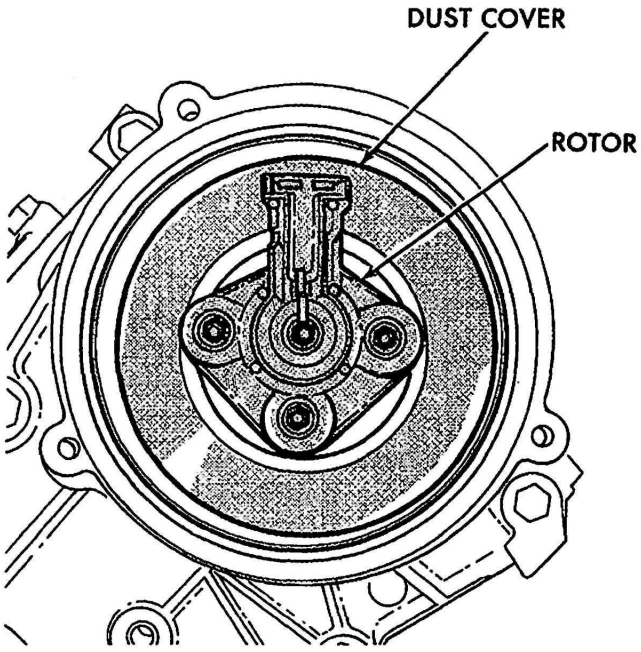
Removal

- Remove the distributor wires from the spark plugs.
- If necessary, remove the distributor cap shield.
- Completely loosen distributor cap screws. (FIG. 19)



(FIG. 19)

- Remove mounting screws that attach the rotor to the distributor drive.
- Remove rotor. (FIG. 20)
- Remove dust cover. (FIG. 20)

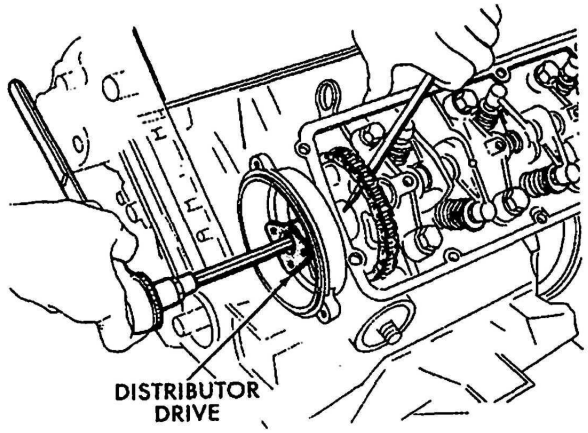


(FIG. 20)

TIMING COVER

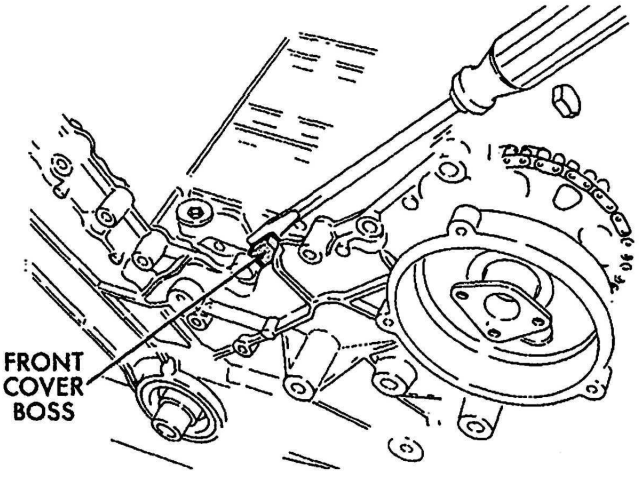
Removal

- Remove Cylinder head covers (as outlined previously)
- Hold the camshaft sprocket in place and remove the distributor drive/camshaft sprocket bolt using socket wrench tool number 7399. (or equivalent) (FIG. 21)
- Pull distributor drive forward and off of the camshaft sprocket.



(FIG. 21)

- Remove the timing cover mounting bolt.
- Place a pry bar between the cylinder block and boss on the front cover and gently pry the cover off. (FIG. 22)
- Remove the gaskets.



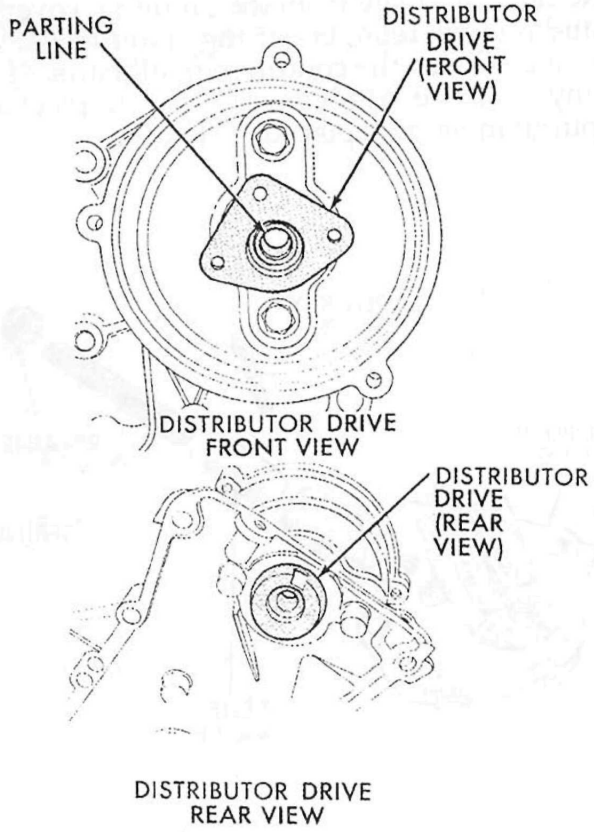
(FIG. 22)

DISTRIBUTOR DRIVE OIL SEAL

Replacement

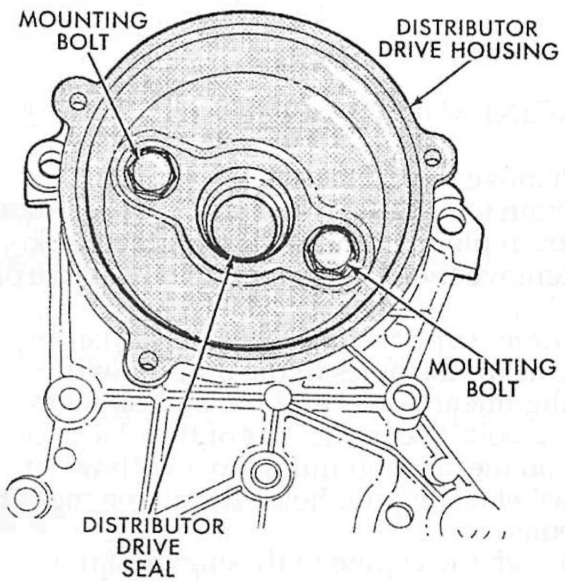
The timing cover must be removed to replace the distributor drive seal.

- Separate the distributor drive; front and rear sections. It may be necessary to use a small drift punch and tap at the parting line to separate the two sections. (FIG. 23)



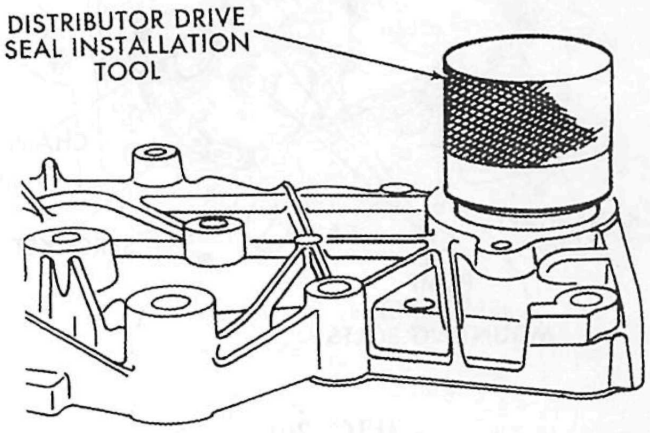
(FIG. 23)

- The distributor drive seal is located behind the distributor housing. (FIG. 24)
- Use a socket to push the old seal out.



(FIG. 24)

- Use tool number 6126 to install the new seal flush with the cover. (FIG. 25)



(FIG. 25)

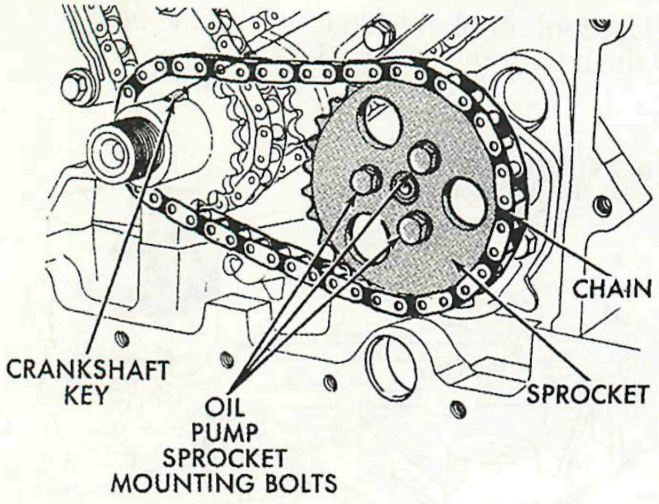
NOTE: *When the distributor housing is re-attached, the seal will be seated to the proper depth in the cover.*

- Install the distributor housing.
- Lightly oil the seal lips.
- Install the distributor drive rear section through the back of the cover, past the seal and up into the distributor housing.
- Line up the dowel in the top of the rear section with the dowel hole in the bottom of the distributor drive front section and tap them together.

OIL PUMP

Removal

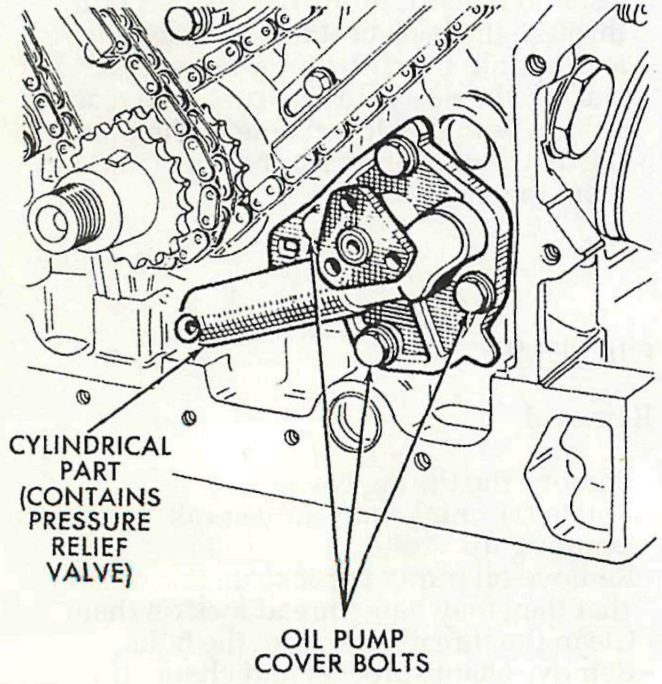
- Remove the timing cover.
- Rotate the crankshaft until crankshaft key is pointing up.
- Remove oil pump sprocket bolts. NOTE, that they may have thread lock on them.
- Clean the thread lock from the bolts.
- Remove chain sprocket and chain. (FIG. 26)



(FIG. 26)

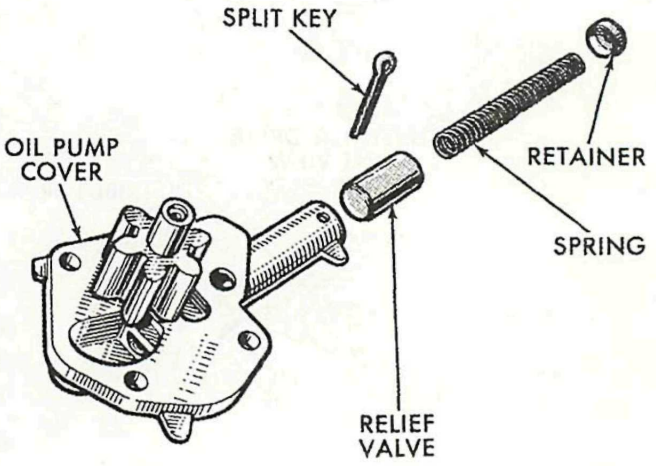
CAUTION: *When removing the oil pump cover, do not strike cylindrical part that contains the pressure relief valve.*

- Remove oil pump cover bolts.
- Remove the oil pump cover. (FIG. 27)



(FIG. 27)

- Remove split key from the oil pump cover and remove retainer, spring, and relief valve. Check the condition of all parts. If any shows excessive wear, the complete oil pump must be replaced. (FIG. 28)



(FIG. 28)

ENGINE SUPPORT BRACKETS TOOL # 6183

- Remove the drive plate.
- Drain the engine water jacket by removing drain plugs from the sides of the block.
- Remove the exhaust manifolds and the oil filter.
- Mount support brackets 6183 to the engine. Line up the holes in the bracket with the alignment dowel and transmission mounting bolt hole in the rear of the block. Position the arm mounting hole with water jacket drain plug hole. Install the mounting bolts.
- Attach the engine to the engine stand.

CYLINDER HEAD

Removal - Timing chains not removed

NOTE: *If only one cylinder head is to be removed (for example to service only one piston and liner assembly or cylinder head gasket), the procedure can be performed without removing the timing chains.*

This procedure can also be performed in the vehicle and is outlined in the service manual.

Right hand Cylinder Head

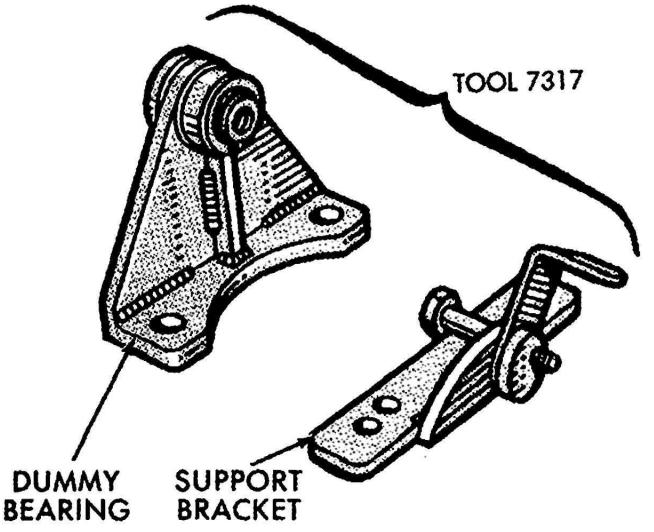
- Remove the spark plug wires and spark plugs.
- Remove the exhaust manifold as outlined previously.
- Remove cylinder head cover as outlined previously.

CAUTION: *Do not remove and install the cylinder head with the exhaust manifold attached to it. This will damage the tabs on the cylinder head gasket during installation.*

- Remove the timing case bolts that thread into the cylinder head and loosen the timing case bolts below the cylinder head one turn.

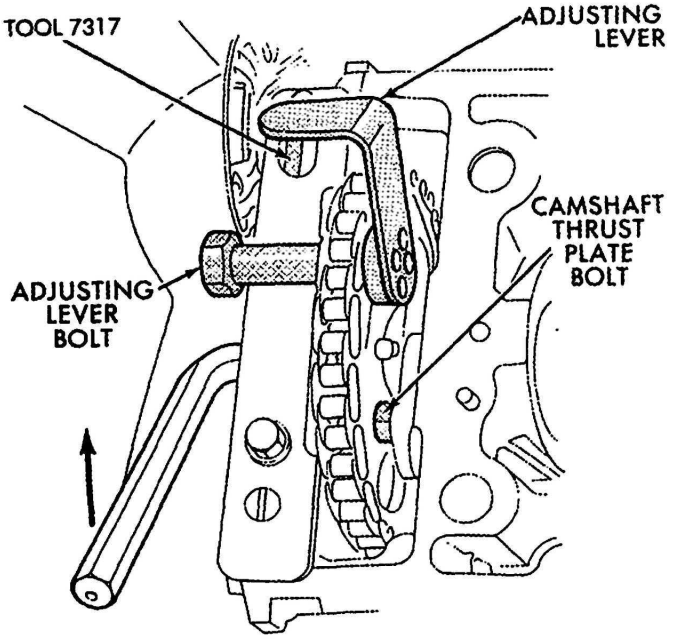
NOTE: *The timing chain and sprockets must be held in place and not allowed to drop down while the cylinder head is removed. If the chain and sprocket slip, the timing case cover must be removed and the chain tensioner released to allow the chain and sprocket to be pulled back up and assembled to the camshaft. The engine will also have to be timed if the chain and sprocket slip down.*

- Use Chain and Sprocket support tool # 7317 which consists of a support bracket and a dummy bearing. Remove bolt and adjusting lever from the support bracket. (FIG. 29)



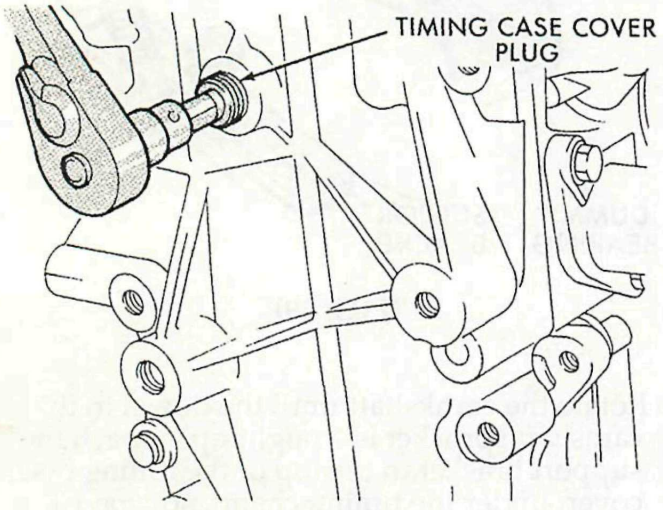
(FIG. 29)

- Rotate the crankshaft until the dowel in the camshaft sprocket is straight up. Attach the support bracket to the top of the timing case cover, under the timing chain and against the camshaft sprocket. Secure the bracket to the timing case cover with the two short cylinder head cover bolts. (FIG. 30)



(FIG.30)

- Position adjusting lever behind the camshaft sprocket. Thread bolt through the front of the tool, thesprocket and into the lever. Push the lever up as far as possible. Tighten the bolt. (FIG.30)
- Un-thread the plug in the front of the timing case cover. This will give access to the cam shaftsprocket bolt. (FIG. 31)



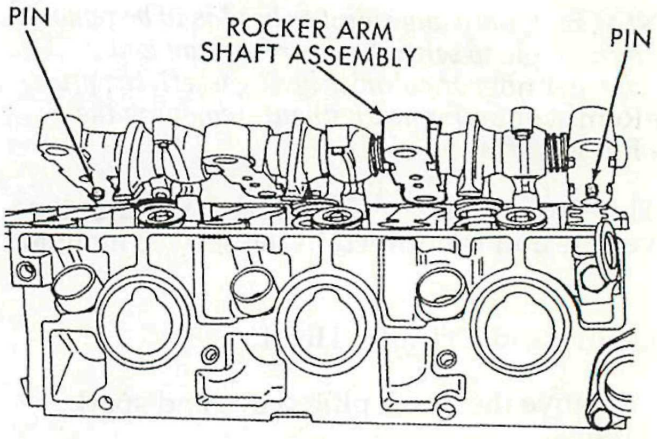
(FIG. 31)

- Remove the camshaft cover and gasket at the rear of the cylinder head.
- Loosen the camshaft thrust plate screw. Pull the plate up and tighten the screw. This will allow the camshaft to move back as the sprocket screw is removed. (FIG. 30)

NOTE: *Attach a wrench or sprocket to the crankshaft pulley nut and prevent the engine from turning while removing the camshaft sprocket bolt.*

- Use Socket tool # 7399, (or a 10mm Allen wrench hex drive socket) to loosen the cam shaft sprocket bolt though the plug hole in the timing case cover. Pull the camshaft back while loosening the sprocket bolt until the bolt is out of the camshaft. The bolt will stay in the sprocket hole. It will not drop down because the timing case cover is too close for it to come out of the sprockets. (FIG. 30)

- Remove the cylinder head bolts.
- Remove the rocker arm shaft assembly. (FIG. 32)

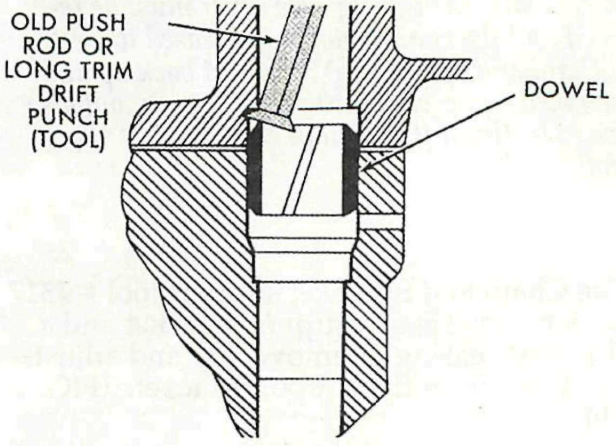


(FIG. 32)

Note that the caps are pinned into the top of the cylinder head and will only go on in one direction.

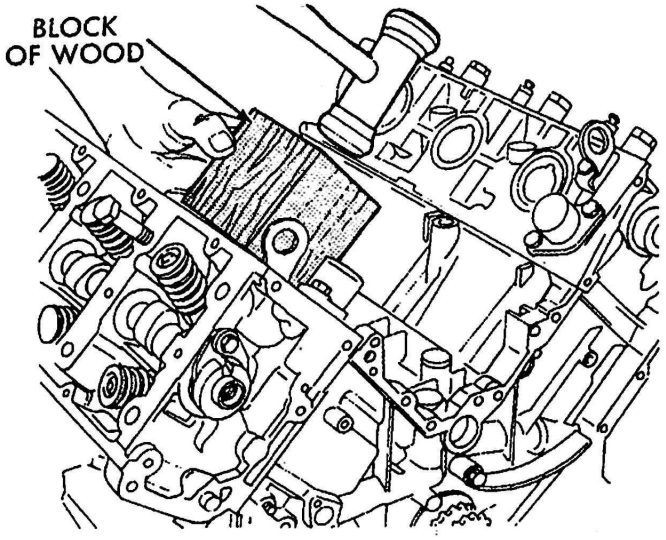
- Install one head bolt in the center and tighten about 1/2 turn.
- Slide the camshaft back away from the sprocket.
- Insert an old push rod or a long thin drift punch into the front and rear cylinder head bolt holes on the exhaust manifold side of the head. Tap the dowels down below the head gasket. (FIG. 33)

NOTE: *Do not lift/pry the cylinder head straight up. this will cause the cylinder liners to come up and out of the block.*



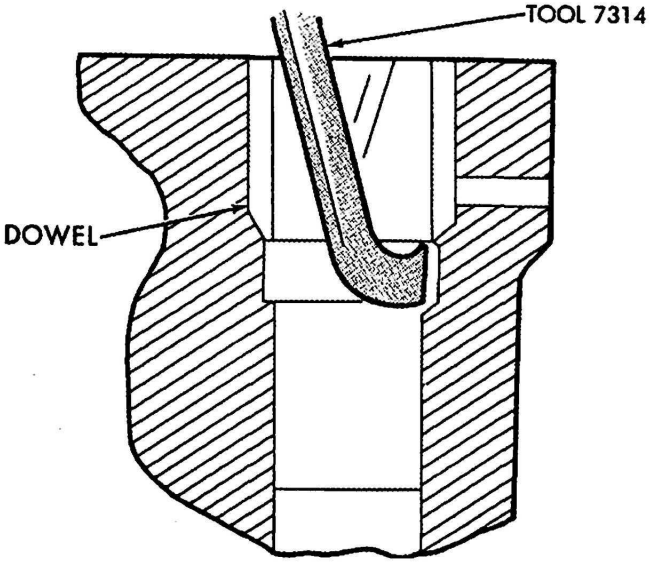
(FIG. 33)

- Position a small piece of wood against the rear intake manifold side of the cylinder head and strike it with a hammer. Now position the piece of wood against the front exhaust manifold side of the cylinder head and strike it with a hammer. Repeat until the cylinder head is loose. (FIG. 34)
- Remove the cylinder head bolt.
- Remove the cylinder head .
- Remove the cylinder head gasket.



(FIG. 34)

- Use tool # 7314 to remove the cylinder head locating dowels from the cylinder block. (FIG. 35)

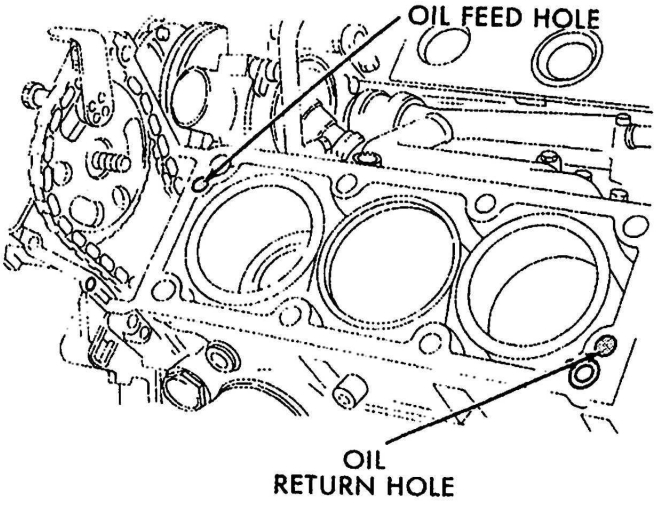


(FIG. 35)

- Stuff the tops of the cylinder bores with clean lint free shop towels.
- Use a gasket removal compound to soften the old gasket material.

CAUTION: *When cleaning the cylinder head and block mating surfaces, do not use a metal scraper because t he surfaces could be cut or grooved. Instead, use a wooden or plastic scraper.*

- Make sure that gasket and/or foreign material does not enter the oil feed hole or oil return hole. (FIG. 36)



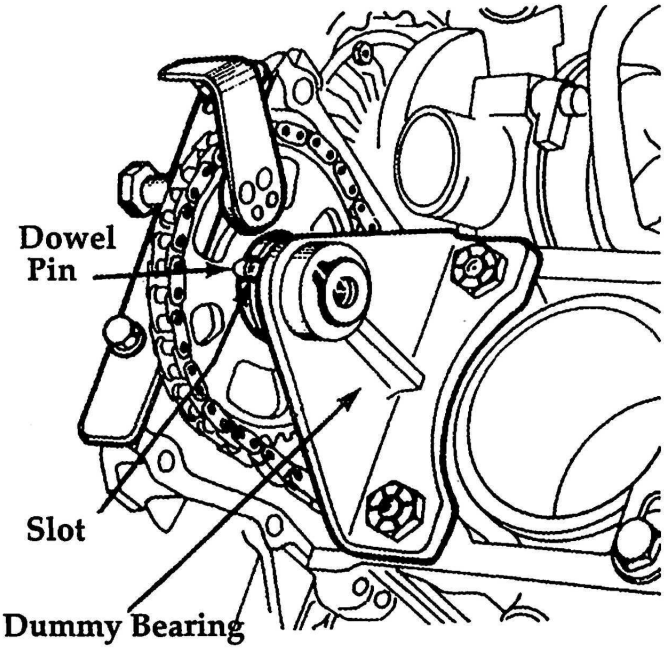
(FIG. 36)

- Rinse and wipe clean the cylinder head mating surfaces.
- Install Cylinder Liner clamps tool #7315 between the cylinder liners to hold them in place.
- If it is necessary to rotate the crankshaft with the cylinder head removed, position the dummy bearing of tool # 7317 against the rear of the timing chain sprocket. Align the slot in the dummy bearing with the dowel pin of the camshaft sprocket.

NOTE: *Do not rotate the crankshaft without having the liner clamps # 7315 installed on the cylinder liners.*

- Screw in and slightly tighten the camshaft sprocket securing bolt.
- If there is a gap between the bottom of the dummy bearing and the top of the cylinder

block, shim with washers to prevent the timing chain sprocket from dropping down and the timing chain tensioner from expand ing.
- Slightly tighten the two bolts securing the dummy bearing to the cylinder block. (FIG. 37)



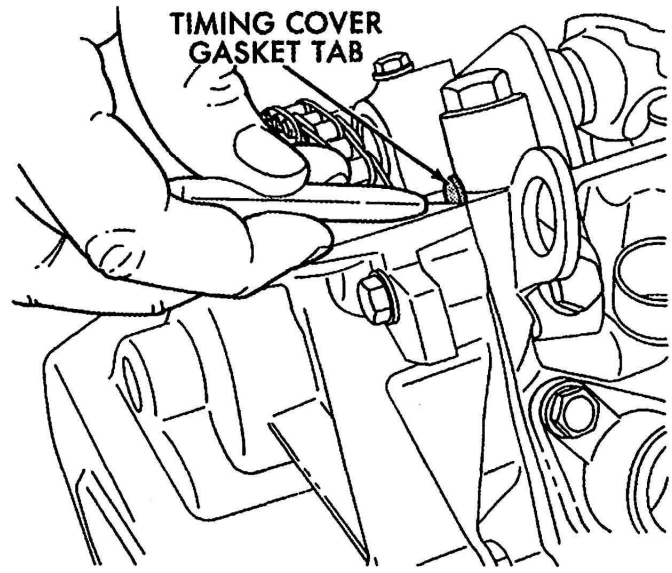
(FIG. 37)

NOTE: *To rotate the engine it will be necessary to remove the support bracket from the camshaft sprocket.*

- Check the liner protrusion. The liner protru sion should be between 0.0051 in. and 0.0078 in. (0.13mm and 0.20mm). Refer to piston liner installation section of this manual.

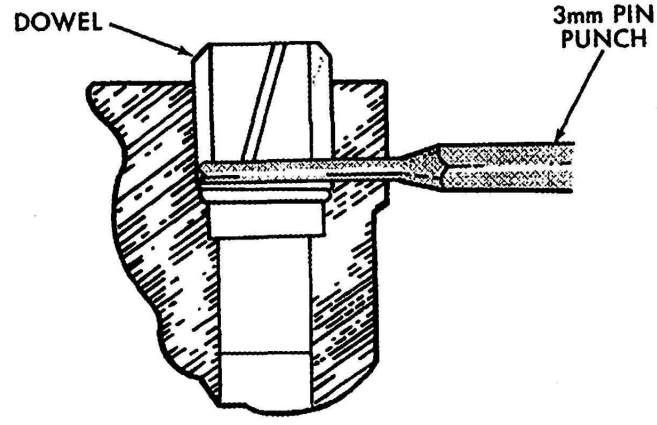
Installation Right Side

- If tool # 7317 dummy bearing was used, re-attach the support bracket from tool # 7317 to the timing case cover and camshaft sprocket. Then remove the dummy bearing.
- Cut the timing case cover gasket flush with the cylinder head gasket face. (FIG. 38)
- Cut sections from the new gaskets. Apply a thin bead of weather strip adhesive and attach them to the timing case cover. Allow to dry.



(FIG. 38)

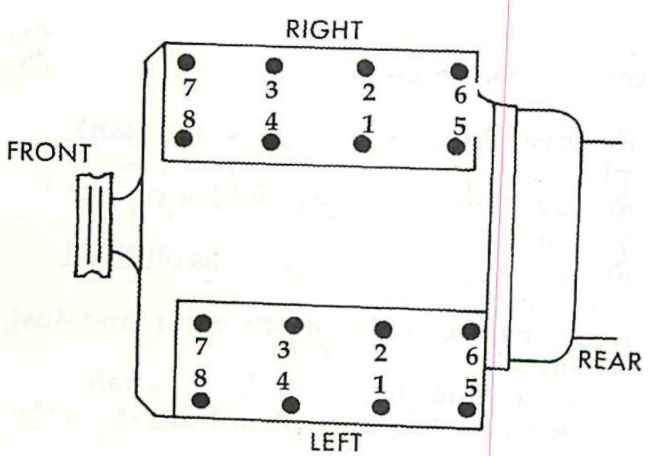
- Install 3mm pin punches into the holes in the block below the locating dowel bolt holes. Push the cylinder head alignment dowels into the holes in the cylinder block until they contact the 3mm pin punches. (FIG. 39)
- Remove the shop towels from the cylinder bores.
- Remove the cylinder liner clamps.



(FIG. 39)

NOTE: *The cylinder head gaskets are not interchangeable between right and left cylinder heads. Be sure you install the correct head gasket to each side.*

- Install a new right-hand cylinder head gasket over the alignment dowels.
- Place a thin strip of RTV gasket in a tube sealer where the cylinder head gasket contacts the timing case cover gasket.
- Install the cylinder head gasket, taking care not to dislodge the timing case cover gasket. Install one cylinder head bolt to keep the cylinder head in place.
- Insert the timing case cover to cylinder head mounting bolts and tighten them finger tight.
- Position the camshaft into the sprocket. Line up the dowel to the slot in the camshaft. Install the sprocket bolt and lightly tighten it.
- Remove tool # 7317 support bracket assembly.
- Loosen the camshaft thrust plate bolt and slide the plate into the groove in the cylinder head. Tighten the bolt to 44 in-lbs (5 N.m) torque.
- Remove the 3mm pin punches.
- Remove the one cylinder head bolt.
- Install rocker shaft assembly and the cylinder head bolts.
- Tighten the cylinder head bolts in the sequence shown. (FIG. 40)



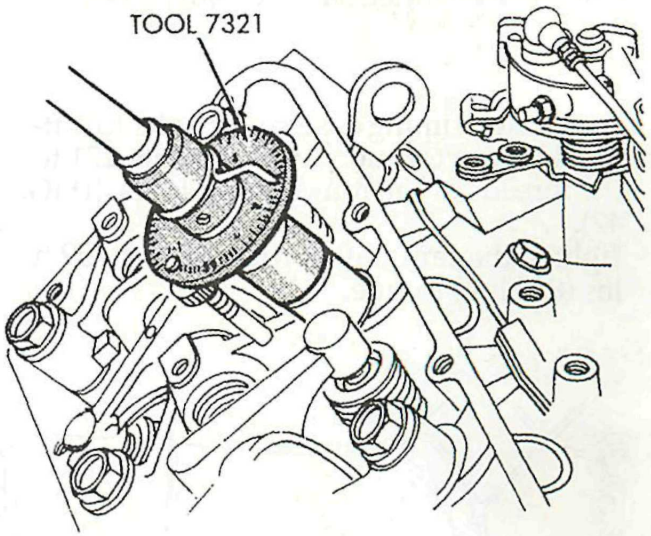
(FIG. 40)

USE THIS PROCEDURE ON ENGINES UP TO AND INCLUDING # 89615.

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

THE FOLLOWING PROCEDURE IS PERFORMED ON ALL BOLTS, ONE AT A TIME.

- Starting with bolt number one, loosen bolt completely.
- Tighten bolt number one to 15 ft-lbs (20 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 between the socket and the wrench. (FIG. 41)



(FIG. 41)

- Angle tighten bolt number one to 106° (+/- 2°).
- Repeat the above procedure for all remaining bolts in the sequence. (FIG. 40)

CAUTION: *Once the engine has been installed in the vehicle the cylinder head re-tightening procedure MUST be performed on Engines built prior to # 89616 (see cylinder head re-tightening section).*

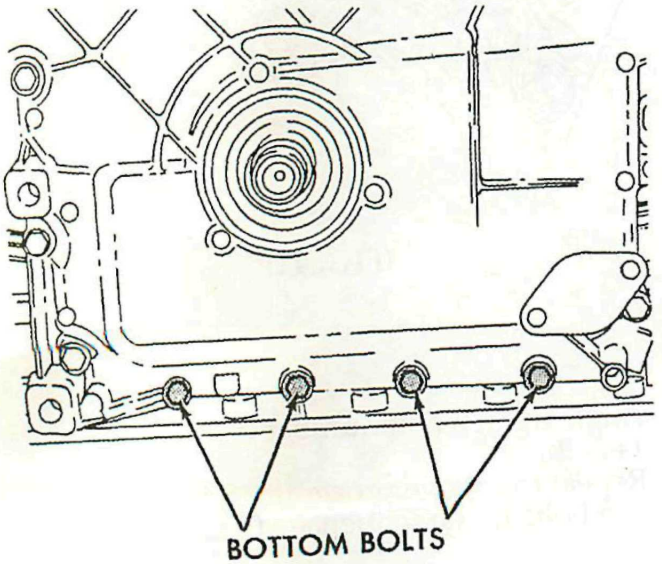
USE THIS PROCEDURE ON ENGINES STARTING WITH # 89616

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque. (FIG. 40)

- Starting with bolt number one, loosen all bolts completely.
- Starting with bolt number one, tighten all bolts to 30 ft-lbs (40 N.m) torque in the se quence shown.
- Install the graduated disc tool # 7321 be tween the socket and the wrench. (FIG. 41)

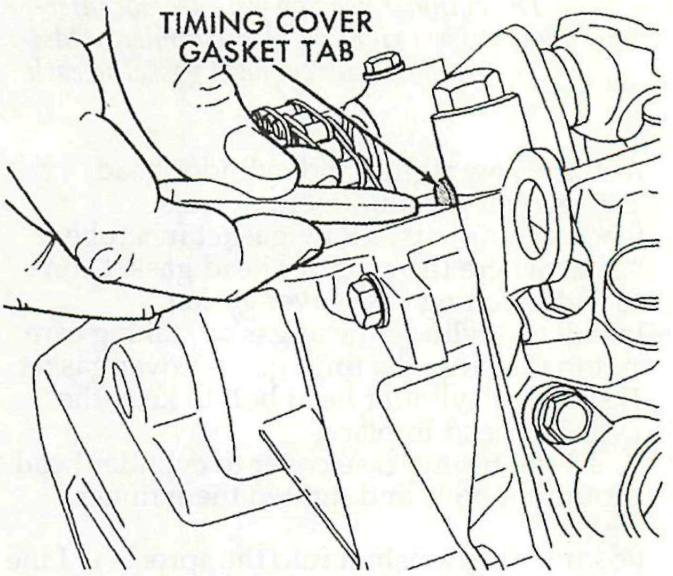
- Angle tighten bolt number one to 180° (+ 0, - 20) and repeat the procedure for all bolts in the sequence. (FIG. 40)

- Tighten the timing case cover bolts to 9 ft-lbs (12 N.m) torque. Apply Loctite 271 to the threads of the four bottom bolts.)(FIG. 42).
- Tighten the camshaft sprocket bolt to 59 ft-lbs (80 N.m) torque.



(FIG. 42)

- Cut off any of the timing case cover gasket protruding above the cylinder head. (FIG.



(FIG. 43)

- Install the cylinder head cover using a new gasket.
- Install the intake manifold with new O-ring gaskets.
- Install the exhaust manifold using new gaskets.
- Install the plug in the front of the timing case cover after coating the threads with Loctite PST pipe sealing with Teflon 592.
- Install the spark plugs.
- Tighten spark plugs to 16 ft-lbs (22N.m) torque.
- Install the spark plug wires.

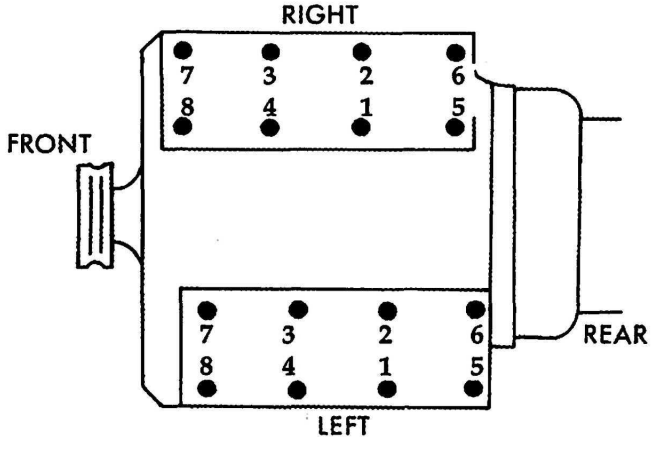
Removal Left Side

- Remove the spark plug wires and spark plugs.
- Remove the exhaust manifold as outlined previously.
- Remove cylinder head cover as outlined previously.
- Remove the distributor cap/rotor/and dust shield.
- Turn the crankshaft until the camshaft sprocket dowel pin is toward the top of the engine.

CAUTION: *Do not remove and install the cylinder head with the exhaust manifold attached to it This will damage the tabs on the cylinder head gasket during installation.*

NOTE: *The cylinder head gaskets are not interchangeable between right and left cylinder heads. Be sure you install the correct head gasket to each side.*

- Install a new right-hand cylinder head gasket over the alignment dowels.
- Place a thin strip of RTV gasket in a tube sealer where the cylinder head gasket contacts the timing case cover gasket.
- Install the cylinder head gasket, taking care not to dislodge the timing case cover gasket. Install one cylinder head bolt to keep the cylinder head in place.
- Insert the timing case cover to cylinder head mounting bolts and tighten them finger tight.
- Position the camshaft into the sprocket. Line up the dowel to the slot in the camshaft. In stall the sprocket bolt and lightly tighten it.
- Remove tool # 7317 support bracket assembly.
- Loosen the camshaft thrust plate bolt and slide the plate into the groove in the cylinder head. Tighten the bolt to 44 in-lbs (5 N.m) torque.
- Remove the 3mm pin punches.
- Remove the one cylinder head bolt.
- Install rocker shaft assembly and the cylinder head bolts.
- Tighten the cylinder head bolts in the sequence shown. (FIG. 40)



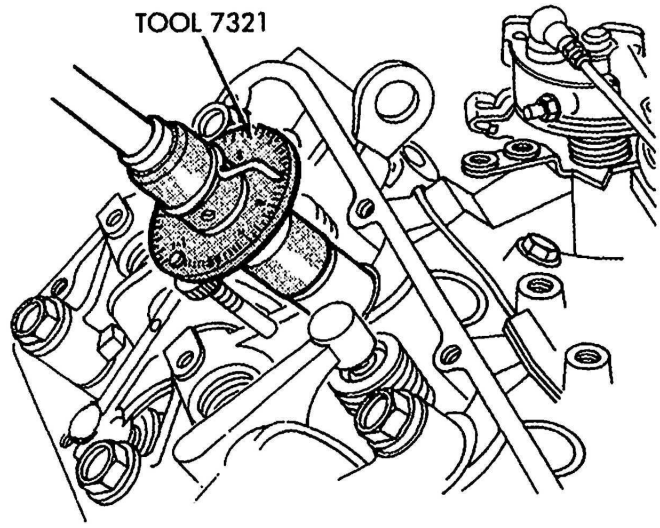
(FIG. 40)

USE THIS PROCEDURE ON ENGINES UP TO AND INCLUDING # 89615.

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

THE FOLLOWING PROCEDURE IS PERFORMED ON ALL BOLTS, ONE AT A TIME.

- Starting with bolt number one, loosen bolt completely.
- Tighten bolt number one to 15 ft-lbs (20 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 between the socket and the wrench. (FIG. 41)



(FIG. 41)

- Angle tighten bolt number one to 106° (+/- 2°).
- Repeat the above procedure for all remain ing bolts in the sequence. (FIG. 40)

CAUTION: ***Once the engine has been installed in the vehicle the cylinder head re-tightening procedure MUST be performed on Engines built prior to # 89616 (see cylinder head re-tightening section).***

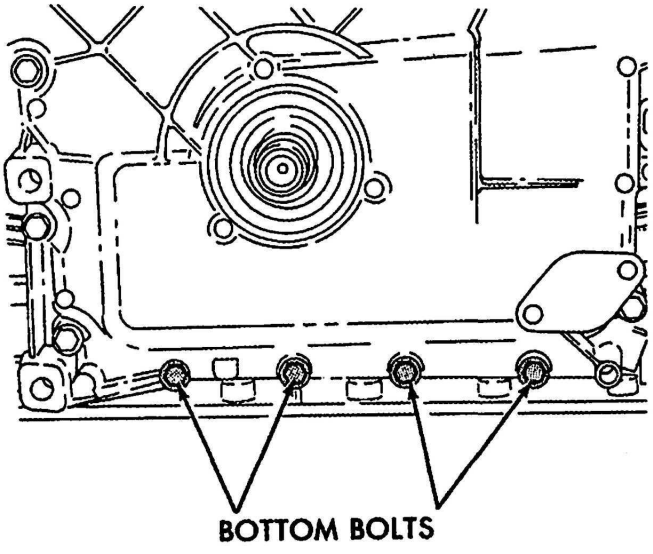
USE THIS PROCEDURE ON ENGINES STARTING WITH # 89616

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque. (FIG. 40)

- Starting with bolt number one, loosen all bolts completely.
- Starting with bolt number one, tighten all bolts to 30 ft-lbs (40 N.m) torque in the se quence shown.
- Install the graduated disc tool # 7321 be tween the socket and the wrench. (FIG. 41)

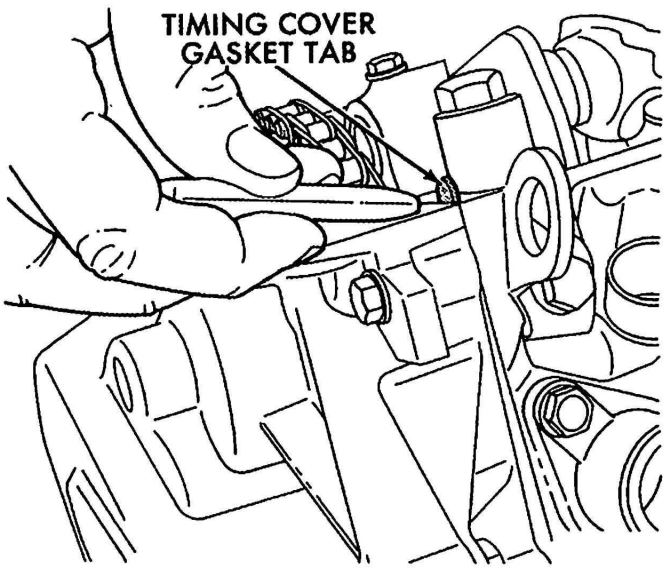
- Angle tighten bolt number one to 180° (+ 0, - 20) and repeat the procedure for all bolts in the sequence. (FIG. 40)

- Tighten the timing case cover bolts to 9 ft-lbs (12 N.m) torque. Apply Loctite 271 to the threads of the four bottom bolts.)(FIG. 42).
- Tighten the camshaft sprocket bolt to 59 ft-lbs (80 N.m) torque.



(FIG. 42)

- Cut off any of the timing case cover gasket protruding above the cylinder head. (FIG. 43)



(FIG. 43)

- Install the cylinder head cover using a new gasket.
- Install the intake manifold with new O-ring gaskets.
- Install the exhaust manifold using new gaskets.
- Install the plug in the front of the timing case cover after coating the threads with Loctite PST pipe sealing with Teflon 592.
- Install the spark plugs.
- Tighten spark plugs to 16 ft-lbs (22N.m) torque.
- Install the spark plug wires.

Removal Left Side

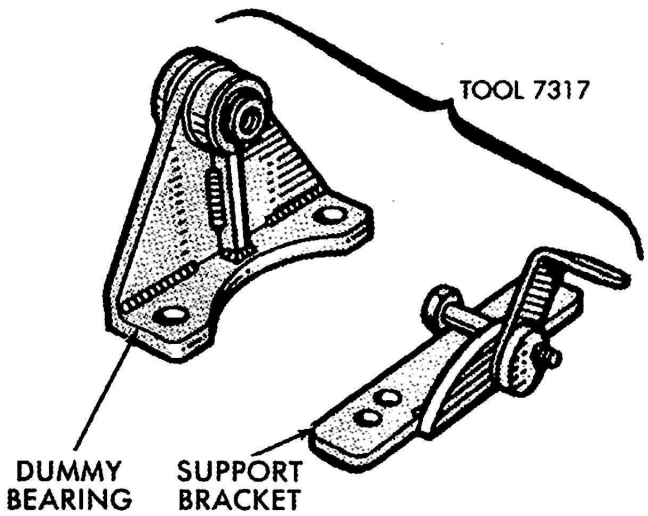
- Remove the spark plug wires and spark plugs..
- Remove the exhaust manifold as outlined previously.
- Remove cylinder head cover as outlined previously.
- Remove the distributor cap/rotor/and dust shield.
- Turn the crankshaft until the camshaft sprocket dowel pin is toward the top of the engine.

CAUTION: *Do not remove and install the cylin der head with the exhaust manifold attached to it This will damage the tabs on the cylinder head gasket during installation.*

NOTE: *The timing chain and sprockets must be held in place and not allowed to drop down while the cylinder head is removed. If the chain and sprocket slip, the timing case cover must be removed and the chain tensioner released to allow the chain and sprocket to be pulled back up and assembled to the camshaft. T he engine will also have to be timed if the chain and sprocket slip down.*

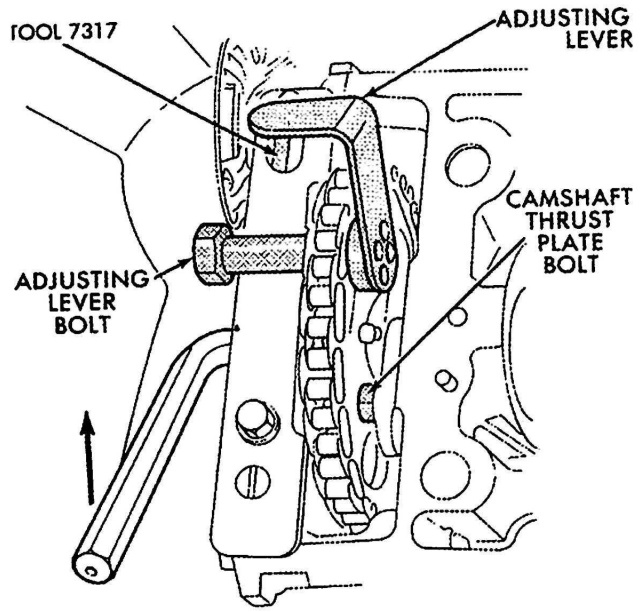
- Use Chain and Sprocket support tool # 7317 which consists of a support bracket and a dummy bearing. Remove bolt and adjust ing lever from the support bracket. (FIG. 44)

- Rotate the crankshaft until the dowel in the camshaft sprocket is straight up. Attach the support bracket to the top of the timing case cover, under the timing chain and against the camshaft sprocket. Secure the bracket to the timing case cover with the two short cylinder head cover bolts.



(FIG. 44)

- Position adjusting lever behind the camshaft sprocket. Thread bolt through the front of the tool, the sprocket and into the lever. Push the lever up as far as possible. Tighten the bolt. (FIG. 45)

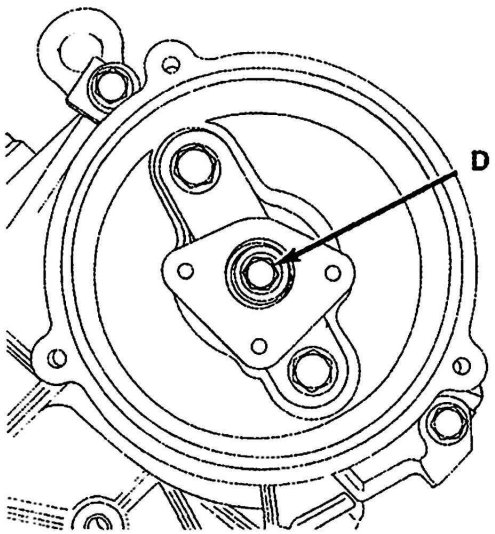


(FIG. 45)

- Remove the timing case cover to cylinder head mounting bolts. Loosen one complete turn the timing case cover bolts that thread into the cylinder block.
- Loosen the camshaft thrust plate screw. Pull the plate up and tighten the screw. This will allow the camshaft to move back as the sprocket screw is removed. (FIG. 45)

NOTE: *Attach a wrench or socket to the crankshaft pulley nut and prevent the engine from turning while removing the camshaft sprocket bolt.*

- Use Socket tool # 7399, (or a 10mm Allen wrench hex drive socket) to loosen the cam shaft sprocket bolt and remove it. (FIG. 46)

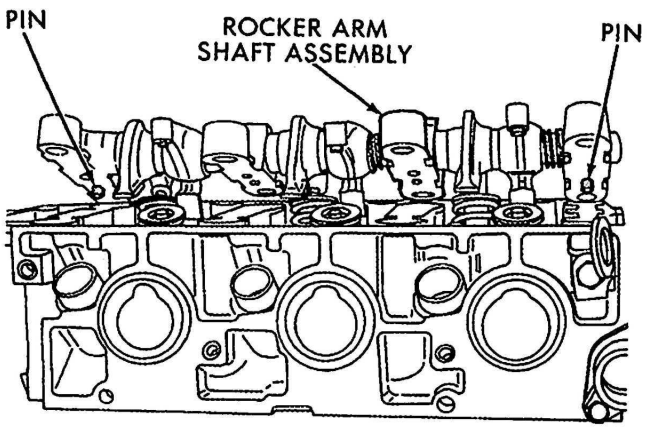


(FIG. 46)

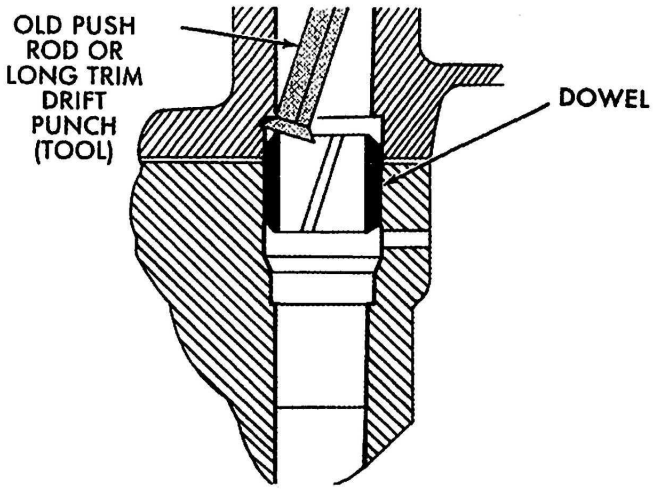
- Remove the camshaft cover plate and gasket at the rear of the cylinder head. Pull the camshaft back and away from the camshaft sprockets.
- Loosen and remove the cylinder head bolts.
- Remove the rocker arm shaft assembly. (FIG. 47)

Note that the caps are pinned into the top of the cylinder head and will only go on in one direction.

- Install one head bolt in the center and tighten about 1/2 turn.
- Insert an old push rod or a long thin drift punch into the front and rear cylinder head bolt holes on the exhaust manifold side of the head. Tap the dowels down below the head gasket. (FIG. 48)



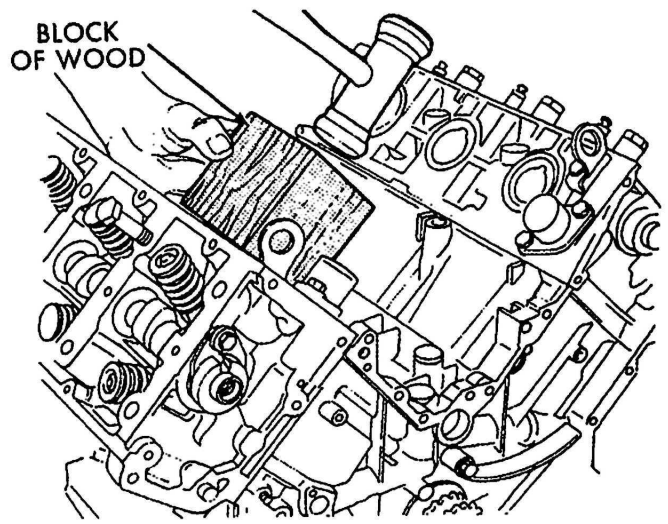
(FIG. 47)



(FIG. 48)

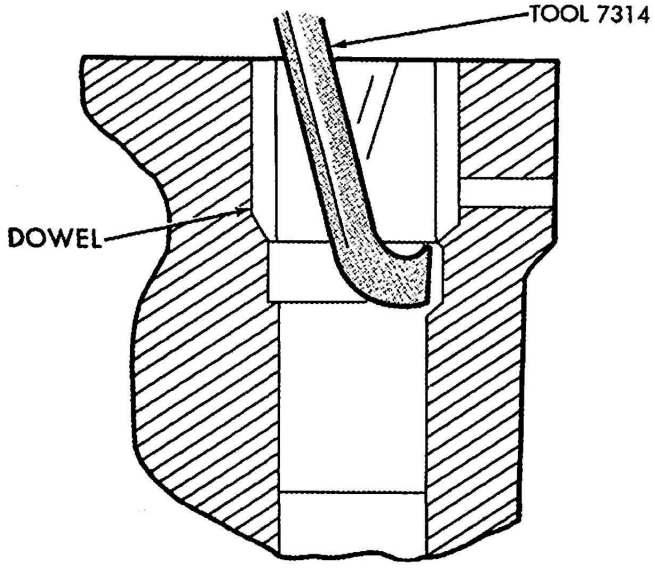
NOTE: *Do not lift/pry the cylinder head straight up. this will cause the cylinder liners to come up and out of the block.*

- Position a small piece of wood against the cylinder head and strike it with a hammer. Repeat on all sides of the cylinder head until the cylinder head is loose. (FIG. 49)



(FIG. 49)

- Remove the cylinder head bolt.
- Remove the cylinder head .
- Remove the cylinder head gasket.
- Use tool # 7314 to remove the cylinder head locating dowels from the cylinder block. (FIG. 50)

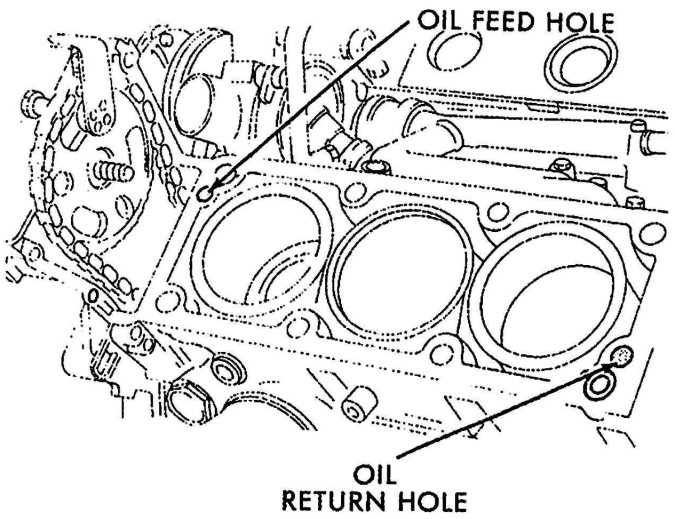


(FIG. 50)

- Stuff the tops of the cylinder bores with clean lint free shop towels.
- Use a gasket removal compound to soften the old gasket material.

CAUTION: *When cleaning the cylinder head and block mating surfaces, do not use a metal scraper because the surfaces could be cut or grooved. Instead, use a wooden or plastic scraper.*

- Make sure that gasket and/or foreign mate rial does not enter the oil feed hole or oil return hole. (FIG. 51)

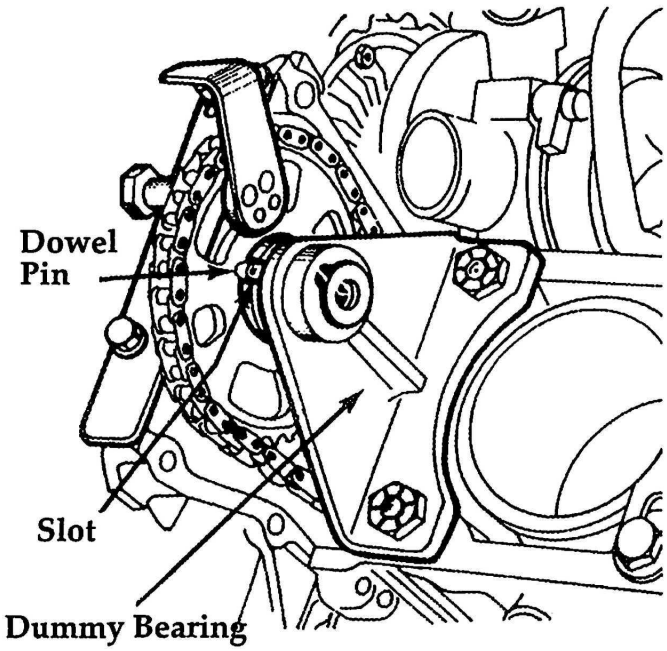


(FIG. 51)

- Rinse and wipe clean the cylinder head mating surfaces.
- Install Cylinder Liner clamps tool #7315 between the cylinder liners to hold them in place.
- If it is necessary to rotate the crankshaft with the cylinder head removed, position the dummy bearing of tool # 7317 against the rear of the timing chain sprocket. Align the slot in the dummy bearing with the dowel pin of the camshaft sprocket. (FIG. 52)

NOTE: *Do not rotate the crankshaft without having the liner clamps # 7315 installed on the cylinder liners.*

- Screw in and slightly tighten the camshaft sprocket securing bolt.
- If there is a gap between the bottom of the dummy bearing and the top of the cylinder block, shim with washers to prevent the timing chain sprocket from dropping down and the timing chain tensioner from expand ing.
- Slightly tighten the two bolts securing the dummy bearing to the cylinder block.



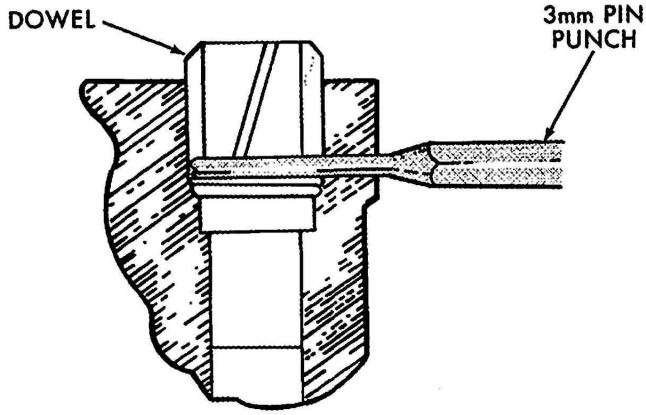
(FIG. 52)

NOTE: *To rotate the engine it will be necessary to remove the support bracket from the camshaft sprocket.*

- Check the liner protrusion. The liner protru sion should be between 0.0051 in. and 0.0078 in. (0.13mm and 0.20mm). Refer to piston liner installation section of this manual.

Installation Left Side

- If tool # 7317 dummy bearing was used, re-attach the support bracket from tool # 7317 to the timing case cover and camshaft sprocket. Then remove the dummy bearing.
- Cut the timing case cover gasket flush with the cylinder head gasket face.
- Cut sections from the new gaskets. Apply a thin bead of weather strip adhesive and attach them to the timing case cover. Allow to dry
- Install 3mm pin punches into the holes in the block below the locating dowel bolt holes. Push the cylinder head alignment dowels into the holes in the cylinder block until they contact the 3mm pin punches. (FIG. 53)



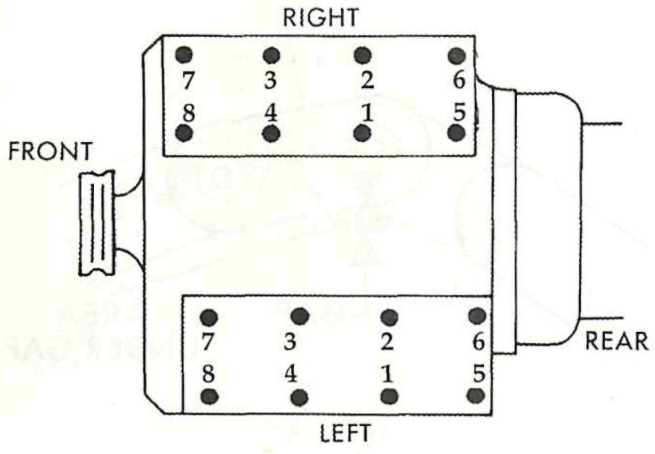
(FIG. 53)

- Remove the shop towels from the cylinder bores.
- Remove the cylinder liner clamps.

NOTE: *The cylinder head gaskets are not interchangeable between right and left cylinder heads. Be sure you install the correct head gasket to each side.*

- Install a new left-hand cylinder head gasket over the alignment dowels.
- Place a thin strip of RTV gasket in a tube sealer where the cylinder head gasket contacts the timing case cover gasket.
- Install the cylinder head gasket, taking care not to dislodge the timing case cover gasket. Install one cylinder head bolt to keep the cylinder head in place.
- Insert the timing case cover to cylinder head mounting bolts and tighten them finger tight.
- Position the camshaft into the sprocket. Line up the dowel to the slot in the camshaft. In stall the sprocket bolt and lightly tighten it.
- Remove tool # 7317 support bracket assembly.
- Loosen the camshaft thrust plate bolt and slide the plate into the groove in the cylin der head. Tighten the bolt to 44 in-lbs (5 N.m) torque.
- Remove the 3mm pin punches.
- Remove the one cylinder head bolt.
- Install rocker shaft assembly and the cylinder head bolts.

- Tighten the cylinder head bolts in the sequence shown. (FIG. 54)



(FIG. 54)

USE THIS PROCEDURE ON ENGINES UP TO AND INCLUDING # 89615.

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

THE FOLLOWING PROCEDURE IS PERFORMED ON ALL BOLTS, ONE AT A TIME.

- Starting with bolt number one, loosen bolt completely.
- Tighten bolt number one to 15 ft-lbs (20 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 between the socket and the wrench.

- Angle tighten bolt number one to 106° (+/-2°).

- Repeat the above procedure for all remaining bolts in the sequence.

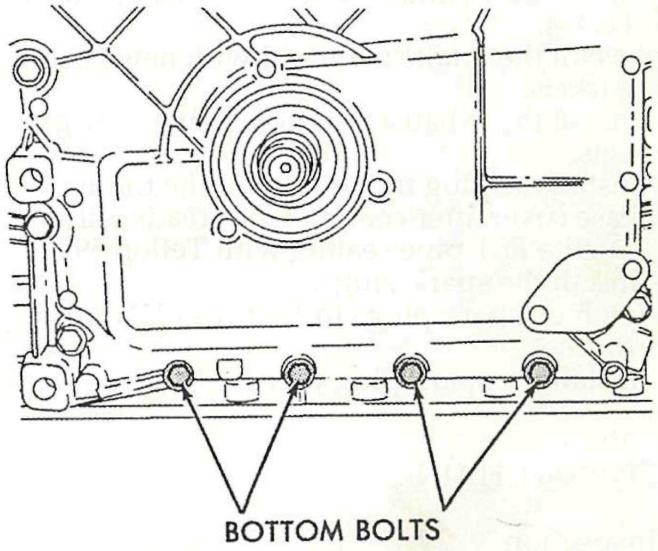
CAUTION: *Once the engine has been installed in the vehicle the cylinder head re-tightening procedure MUST be performed on Engines built proir to number 89616 (see cylinder head re-tightening section).*

USE THIS PROCEDURE ON ENGINES STARTING WITH # 89616

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque. (FIG. 54)

- Starting with bolt number one, loosen all bolts completely.
- Starting with bolt number one, tighten all bolts to 30 ft-lbs (40 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 between the socket and the wrench.

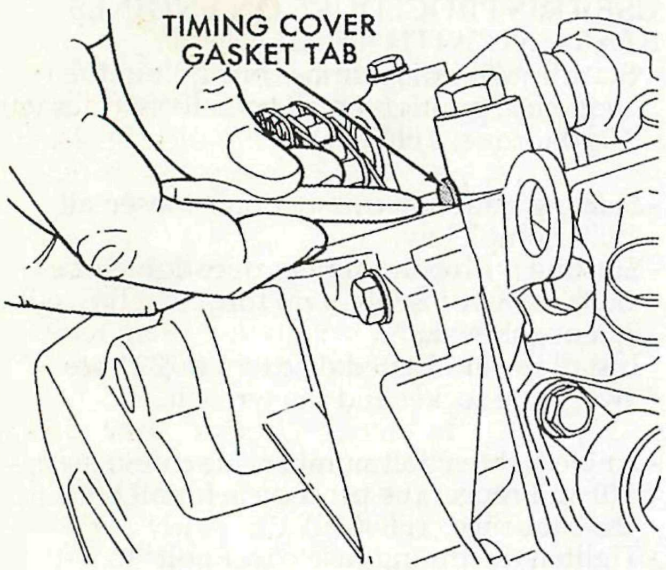
- Angle tighten bolt number one to 180° (+ 0, - 20) and repeat the procedure for all bolts in the sequence. (FIG. 54)
- Tighten the timing case cover bolts to 9 ft-lbs (12 N.m) torque. Apply Loctite 271 to the threads of the four bottom bolts. (FIG. 55)



(FIG. 55)

- Tighten the camshaft sprocket bolt to 59 ft-lbs (80 N.m) torque.

- Cut off any portion of the timing case cover gasket protruding above the cylinder head. (FIG. 56)



(FIG. 56)

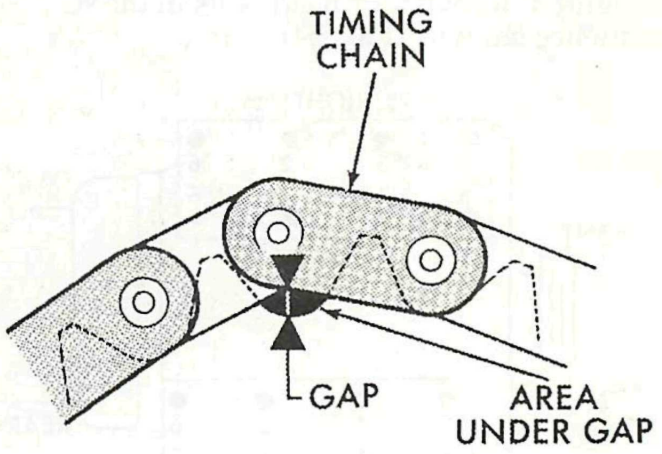
- Install the cylinder head cover using a new gasket.
- Install the intake manifold with new O-ring gaskets.
- Install the exhaust manifold using new gaskets.
- Install the plug in the front of the timing case cover after coating the threads with Loctite PST pipe sealing with Teflon 592.
- Install the spark plugs.
- Tighten spark plugs to 16 ft-lbs (22N.m) torque.
- Install the spark plug wires.

TIMING CHAIN

Inspection

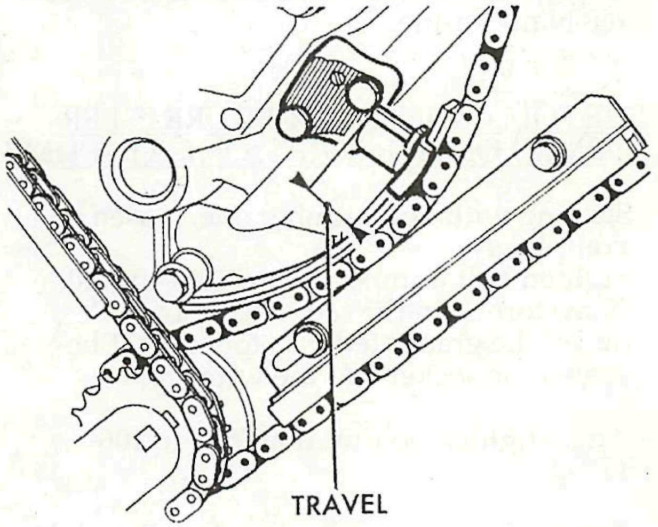
NOTE: Check the timing chain and sprocket for wear. If either side has excessive wear, replace the timing chains, sprocket guide shoes, and tensioners for **BOTH** sides.

- Remove the cylinder head cover.
- Pull on the top of the timing chain. This will produce a gap between the bottom of the timing chain and the bottom of the area between the two sprocket teeth. (FIG. 57)



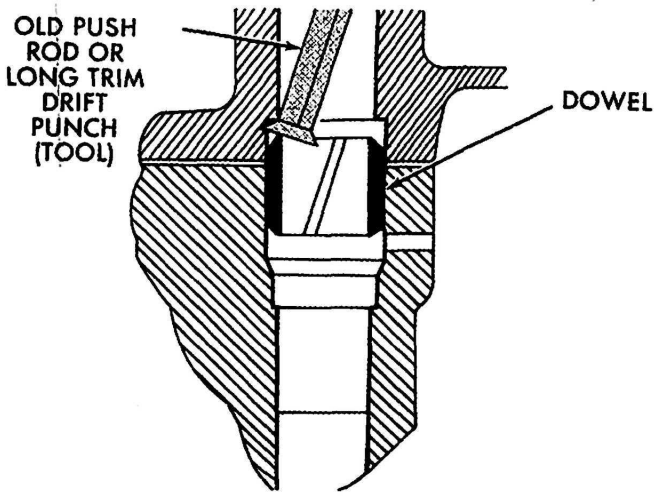
(FIG. 57)

- A maximum clearance of 0.067 in (1.7mm) between the timing chain and sprocket must not be exceeded. A gap of 0.067 in. (1.7mm) corresponds to a travel of (X) = 0.866 in. (22mm) by the timing chain tensioner plunger. (FIG. 58)



(FIG. 58)

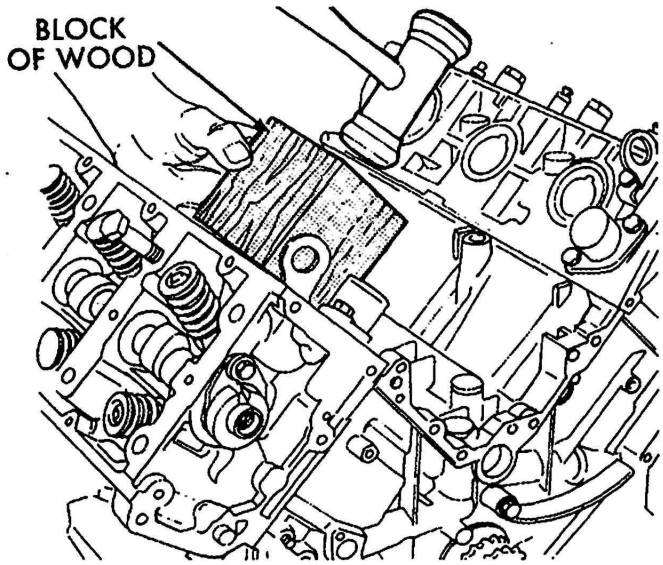
- Use the SOLID END of a number 51 drill bit (0.067 in. - 1.7mm in diameter) to gauge the size of gap. (FIG. 59)



(FIG. 64)

NOTE: *Do not lift/pry the cylinder head straight up, this will cause the cylinder liners to come up and out of the block.*

- Install one cylinder head bolt into a center hole to hold the cylinder head in place.
- Position a small piece of wood against the rear intake manifold side of the cylinder head and strike it with a hammer. Now position the piece of wood against the front exhaust manifold side of the cylinder head and strike it with a hammer. Repeat until the cylinder head is loose. (FIG. 65)

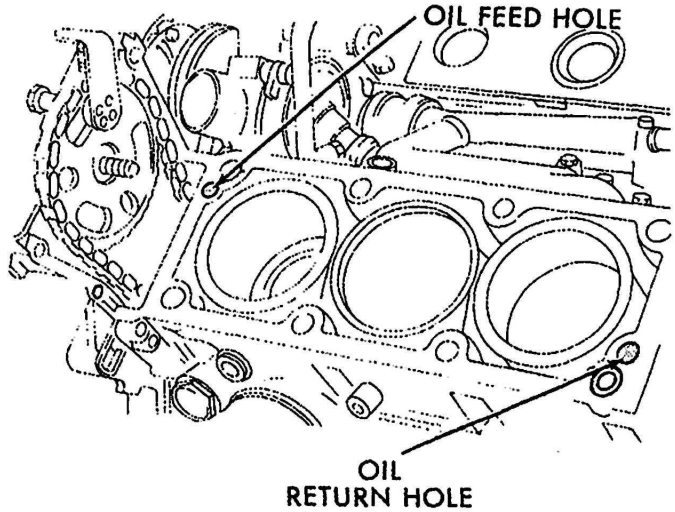


(FIG. 65)

- Remove the cylinder head bolt.
- Remove the cylinder head.
- Remove the cylinder head gasket.
- Use a gasket removal compound to soften the old gasket material.

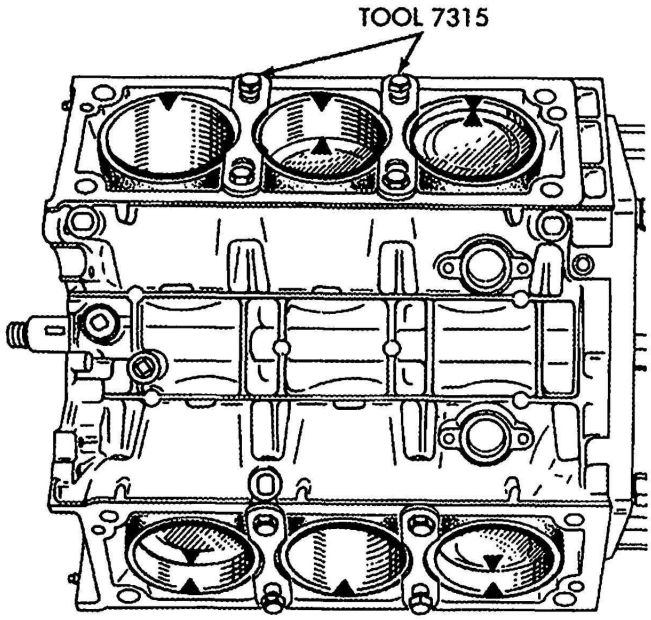
CAUTION: *When cleaning the cylinder head and block mating surfaces, do not use a metal scraper because the surfaces could be cut or grooved. Instead, use a wooden or plastic scraper.*

- Make sure that gasket and/or foreign material does not enter oil feed hole or oil return hole. (FIG. 66)



(FIG. 66)

- Rinse and wipe clean the cylinder block and cylinder head mating surfaces.
- Use tool # 7314 to remove the cylinder head locating dowels.
- Install liner clamp tool # 7315 between the cylinder liners to hold them in place. (FIG. 67)



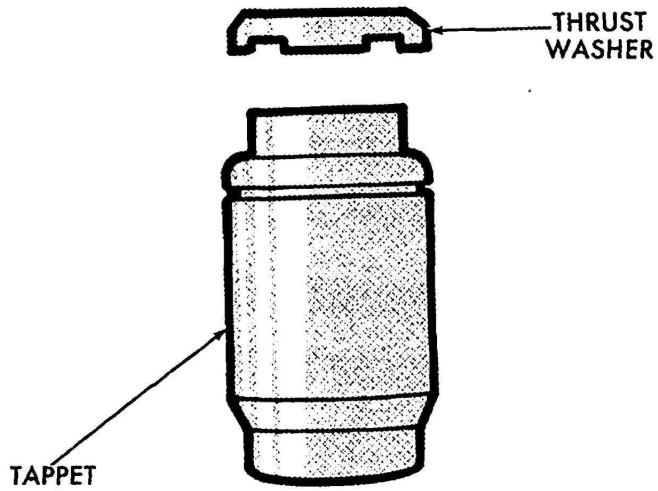
(FIG. 67)

HYDRAULIC TAPPET AND ROCKER ARM

A hydraulic tappet is located in each rocker arm. the tappet is in constant contact with the top of the valve stem and is not adjust able. Valve lash is always zero. Oil pumped through the rocker shaft reaches the tappet through a passage in the rocker arm. The oil passes under slots in the tappet thrust washer and into the tappet body. Air and oil are bled off through two small holes above the thrust washer. A squirt hole lubricates the camshaft lobe.

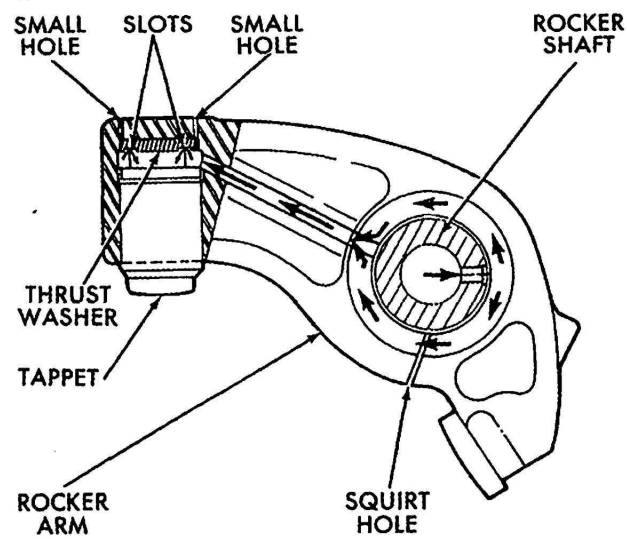
Disassembly

- Disassemble the rocker shaft assembly as outlined previously in this manual.
- Remove tappet from the rocker arm.
- Remove thrust washer. (FIG. 68)



(FIG. 68)

- Use a straight edge to check the bottom of the tappet for a crown. If the tappet is worn flat or dished, replace it.
- Check the oil squirt hole in the rocker arm for blockage. Use compressed air to clean out any blockage. (FIG. 69)
- Check cam follower pad of the racker arm for wear. If the pad is flat and does not have a crown, replace the rocker arm and check the accompanying camshaft lobe for wear. (FIG. 69)
- Clean the rocker arms. Use compressed air to clean out the oil passage from the rocker shaft bore to the tappet bore and the oil squirt hole. (FIG. 69)



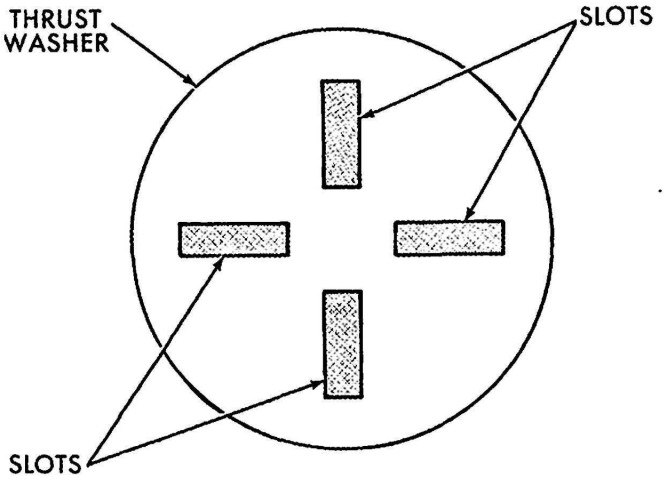
(FIG. 69)

Assembly

- Lightly coat the tappet, thrust washer and tappet bore with clean engine oil.

CAUTION: *When installing thrust washer, the slots must face the tappet. If the washer is installed incorrectly, oil will not enter the tappet.*

- Install the thrust washer with the slots toward the tappet. (FIG. 70)
- Install the tappet.



(FIG. 70)

NOTE: *The tappet may tend to fall out of the tappet bore. It may be necessary to use masking tape or tag wire to hold the tappet in place until the rocker shaft assembly is installed on the engine.*

ROCKER SHAFT

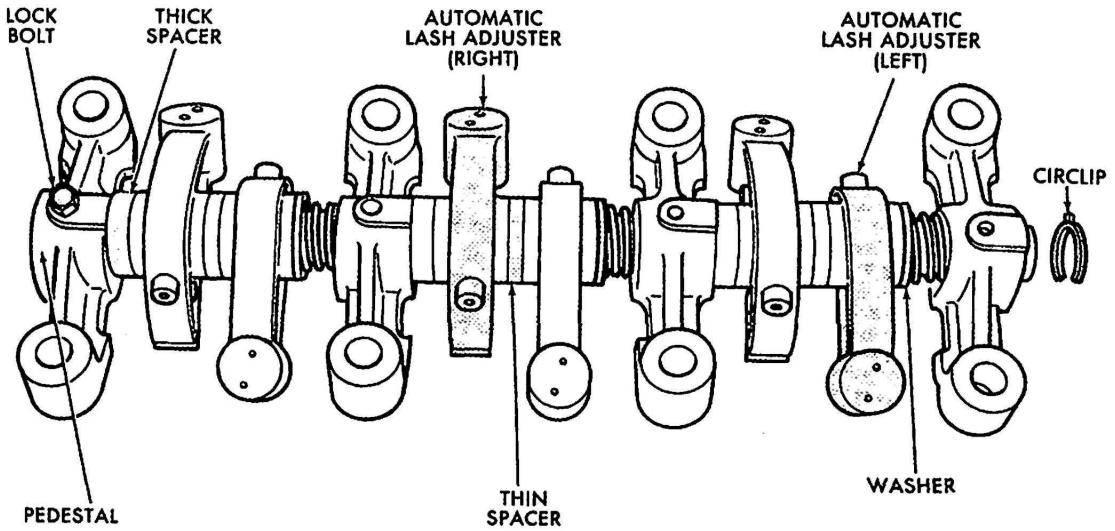
- The left and right hand rocker shaft assemblies are identical and can be used on either cylinder head. When reusing rocker arm assemblies, always install them on the same cylinder head that they were removed from.

Disassembly (FIG. 71)

NOTE: *The oil galley plugs in the ends of the rocker shafts are pressed in and are not replaceable.*

NOTE: *When disassembling, arrange parts in the order that they were removed.*

- Remove the lock screw and carefully remove in order:
  - Pedestal
  - Thick Spacer
  - Rocker arm with automatic lash adjuster on the right
  - Thin spacer
  - Rocker arm with automatic lash adjuster on left
  - Spring
  - Washer
- Remove the circlip from the end of the rocker shaft. (FIG. 71)



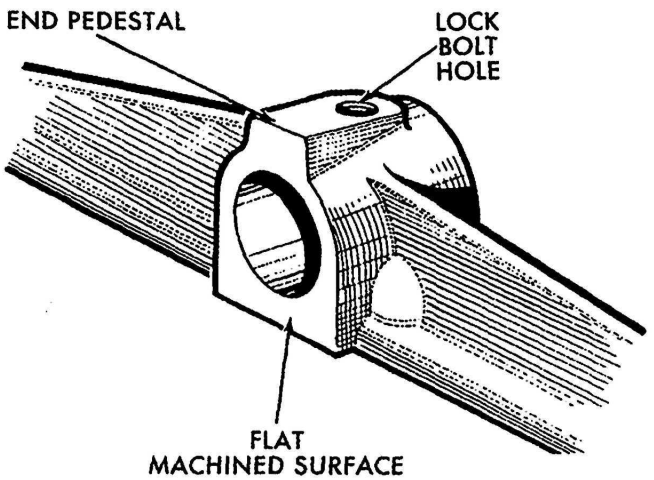
(FIG. 71)

Assembly

- The rocker shaft can be installed only one way. There are two holes in the one end of the rocker shaft (top and bottom). The larger hole is at the top. This hole lines up with set bolt when screwed into the pedestal. The lock screw will not fit into the smaller (bottom) hole. The circlip fits onto the other end of the shaft.

NOTE: *The oil feed holes in the rocker shaft must be clean and unplugged to ensure that oil travels to the rocker arm, automatic lash adjuster and the camshaft.*

- When assembling, be sure that flat machined surface of the pedestal faces the circlip. (FIG. 72)

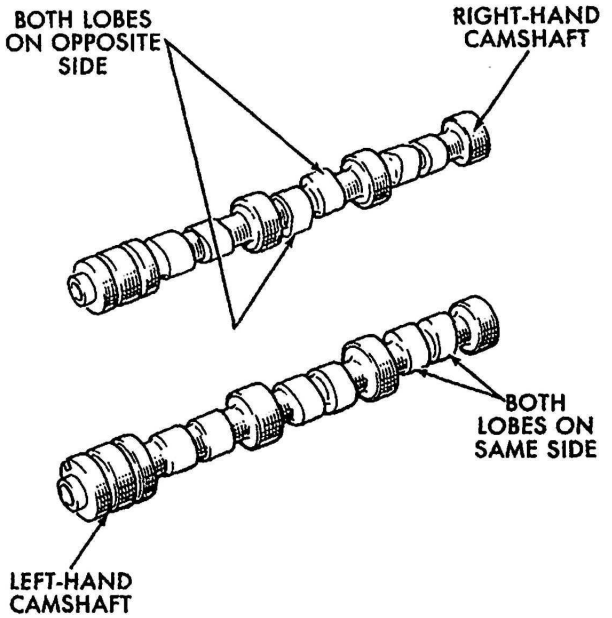


(FIG. 72)

- Lightly coat the rocker shaft with clean oil.
- Completely assemble rocker shaft in the correct order. Insert the lock screw and tighten it to 53 Inch-lbs. (6 N.m) Torque.

CAMSHAFTS

The right and left hand camshafts are not the same and cannot be interchanged. The camshafts can be identified by the location of the cam lobes. (FIG. 73)



(FIG. 73)

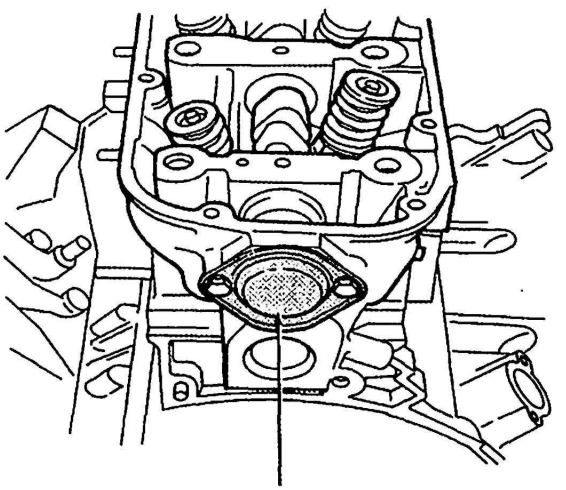
On the left hand camshaft, Both lobes for each cylinder are on the ***same side.*** (FIG. 73)

On the right camshaft, the lobes for each cylinder are on ***opposite sides.*** (FIG. 73)

The Camshafts are removed and installed from the rear of the cylinder heads once they have been removed.

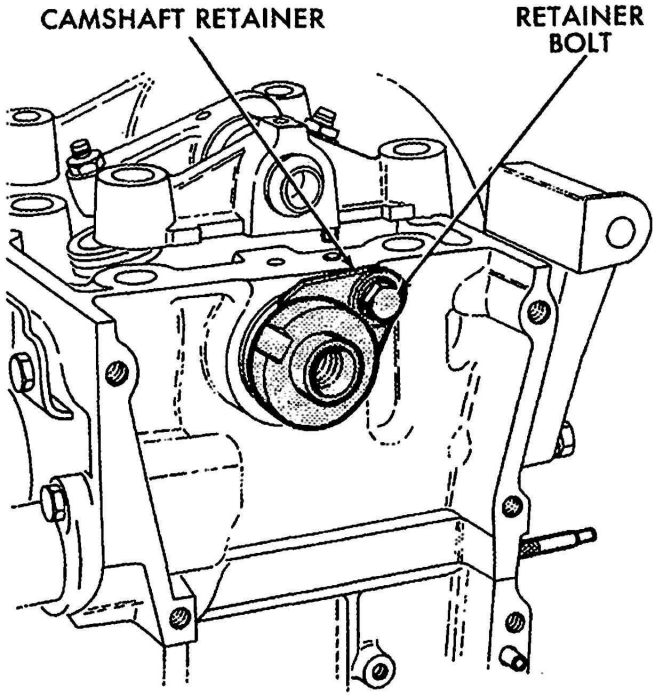
Removal

- Remove camshaft cover at the rear of the cylinder head. (FIG. 74)



(FIG. 74)

- Loosen camshaft retainer bolt and slide retainer up and out of the groove in the cam shaft. Tighten the bolt. (FIG. 75)



(FIG. 75)

- Slide the camshaft out the rear of the cylinder head.
- Replace any camshaft with worn lobes.

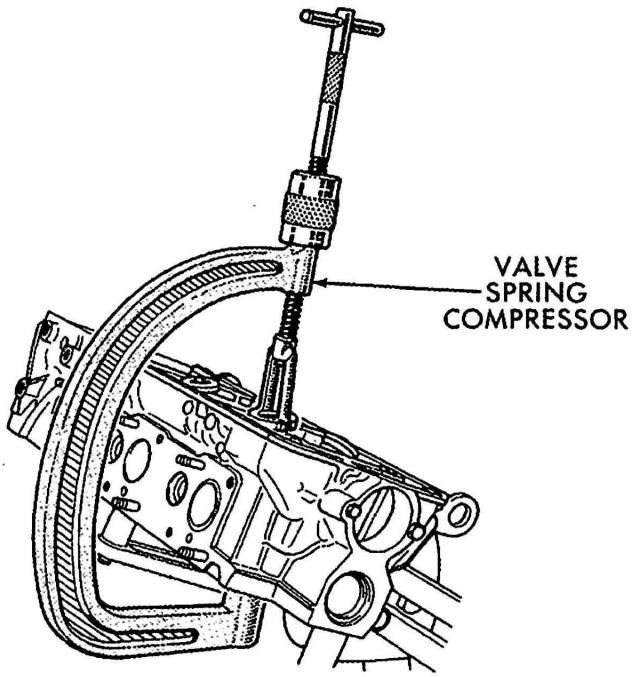
CYLINDER HEAD COMPONENT

Remove the cylinder head as outlined previously in this manual.

Disassembly

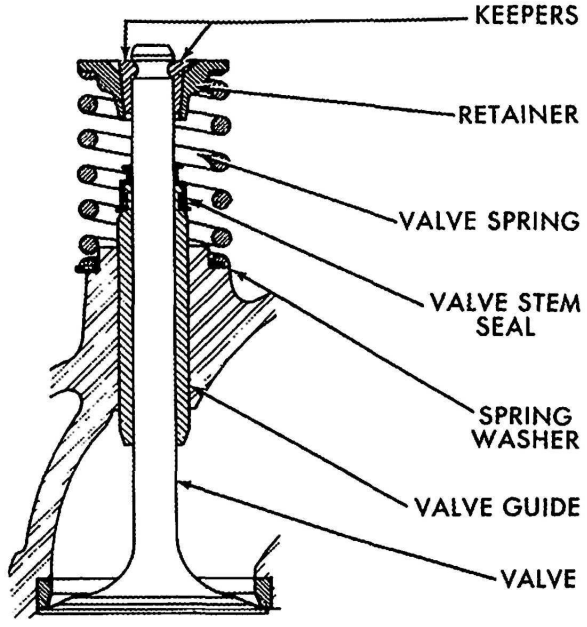
- Use a valve spring compressor to compress the valve spring. (FIG. 76)
- Remove keepers, valve springs, spring washers and lay them out in the order that they were removed. (FIG. 77)

NOTE: *Check the valve keeper groove in the top of the valve stem for burrs prior to removing the valves. If burrs are found remove them with a jewelers file. Failure to remove the burrs will cause damage to the valve guide when the valve is removed.*



(FIG. 76)

- Use a grease pencil to mark the bottom of the valve with its cylinder.
- Remove the valve from the guide and place it with the corresponding valve spring, keepers, retainer, and washer.
- Remove valve stem seal from the top of the valve guide.



(FIG. 77)

INTAKE VALVE

FACE ANGLE	45°
FACE WIDTH	0.057" - 0.087" (1.45mm - 2.21mm)
MIN. MARGIN	0.059" (1.5mm)

EXHAUST VALVE

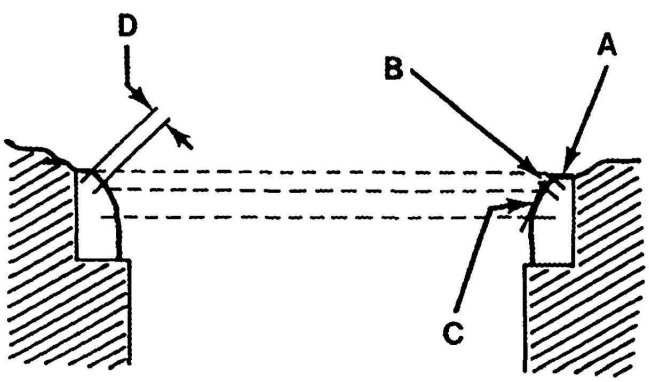
FACE ANGLE	45°
FACE WIDTH	0.063" - 0.104" (1.6 mm - 2.64mm)
MIN. MARGIN	0.067" (1.7mm)

INTAKE AND EXHAUST SEAT (FIG. 78)

TOP ANGLE (A)	8°
SEAT ANGLE (B)	45°
THROAT ANGLE (C)	60°

SEAT WIDTH (D)

INTAKE	0.051" - 0.067" (1.3mm - 1.7mm)
EXHAUST	0.076" - 0.095" (2.0mm - 2.4mm)



(FIG. 78)

VALVE GUIDES

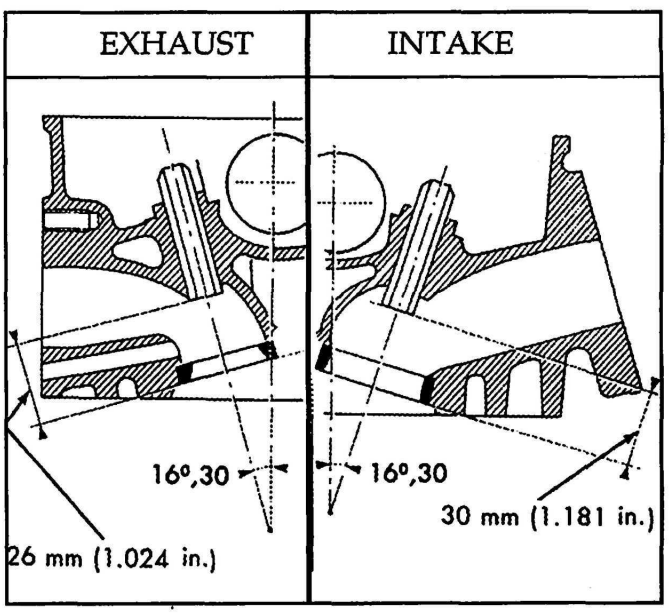
There are two available repair size valve guides. The repair guide outside diameter (size) can be identified by the number of grooves on the outside of the guide.

NORMAL (NO GROOVES)	0.512" (13.0mm)
REPAIR (TWO GROOVES)	0.526" (13.25mm)

- Press the old valve guides out of the cylinder head. Count the number of grooves on the outside of the old guide to determine which repair size guide can be used. Do not install the same size guide as the one that was removed.

NOTE: *The new valve guide must be installed with a 0.0039 in. (0.1mm) interference fit between the guide and the valve guide bore. The valve guide bores in the cylinder head must be machined to the appropriate diameter for the repair valve guide selected. The angle is 16.5°.* (FIG. 79)

- Press the intake valve guides in until the bottom of the valve guide is 1.181in. (30mm) from the top of the valve seat.



(FIG. 79)

- Press the exhaust valve guides in until the bottom of the valve guide is 1.024 in. (26mm) from the top of the valve seat.
- After the new guides are installed, ream the valve guides to 0.315in. (8mm) and then grind the valve seats.

NOTE: *To insure proper sealing between the valve and valve seats, the valve seats must be ground after a new valve guide has been installed and reamed to 0.315in. (8mm).*

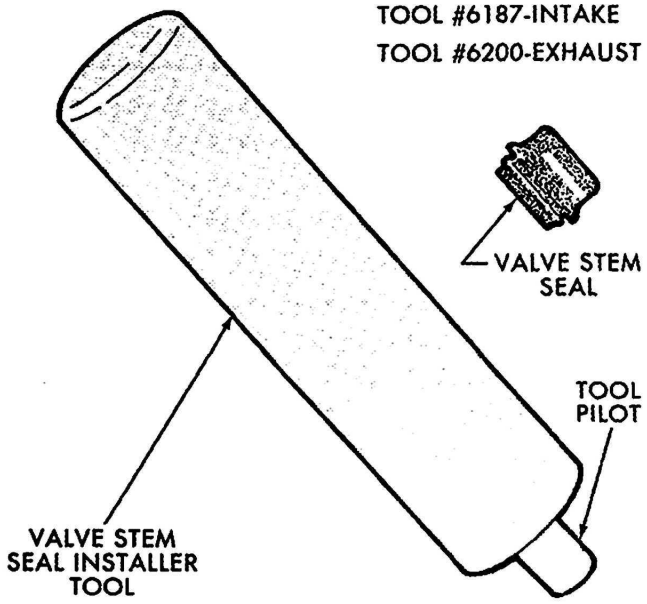
- Clean the cylinder heads. Remove all metal chips and grinding dust from the valve guides and combustion chambers.

Assembly

Prior to assembling the cylinder head, stick each valve into its appropriate guide and slowly move it in and out. The valve should slide without drag. If drag is felt, check both the guide and the valve stem for burrs.

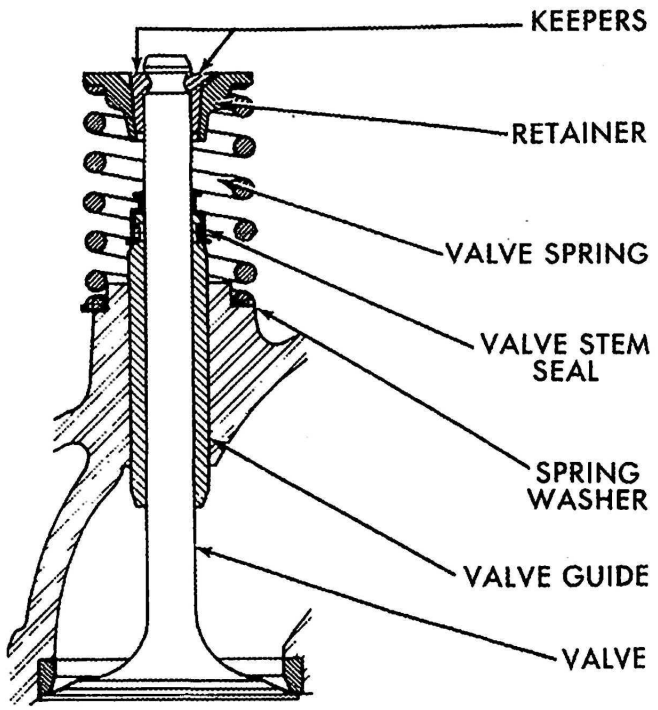
NOTE: *There are two valve stem seal installers. # 6187 is silver in color and stamped INTAKE. # 6200 is gold in color and stamped EXHAUST.*

- Using the correct tool, install the valve stem seals. (FIG. 80)



(FIG. 80)

- Position the seal on the tool pilot.
- Install the pilot into the top of the valve guide and gently push down.
- Use a rubber mallet to lightly tap on the top of the seal installer until the tool stops. Remove the tool from the valve guide.
- Lightly oil the valve guide stems and install them into the valve guides.
- Install spring washers, valve springs, retainers, and keepers. (FIG. 81)



(FIG. 81)

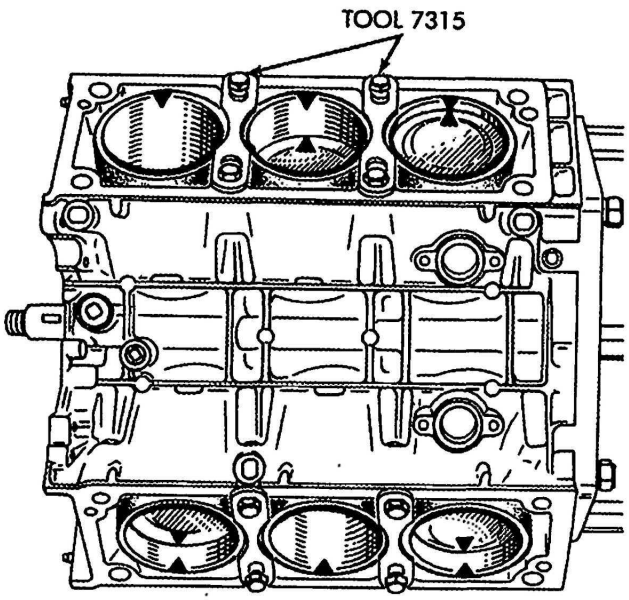
OIL PAN

Removal

- Drain the engine oil.

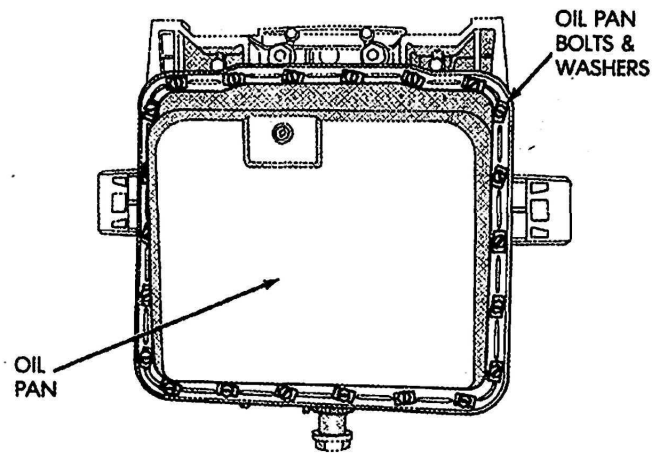
NOTE: *If the piston - liner assemblies will be removed, install liner clamp tool #7315 across the 4 center head bolts to keep the liners in place.* (FIG. 82)

- Rotate the engine on the stand until the oil pan is pointing upward.
- Remove the oil pan bolts and washers.
- Remove the oil pan. (FIG. 83)



(FIG. 82)

CAUTION: *Do not use a metal scraper to remove the gasket material from the lower casing, it could cut or groove the casing. Instead, use a wooden or plastic scraper.*



(FIG. 83)

- Clean old gasket material from the lower casing.
- Clean the oil pan.

Installation

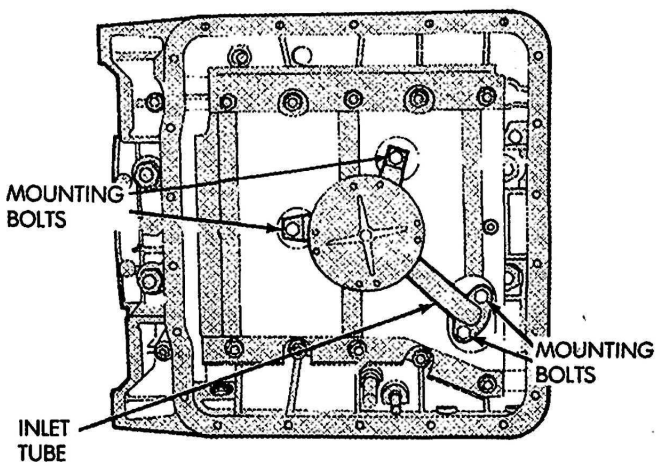
- Install a new oil pan gasket (dry).
- Position the oil pan over the lower casing and gasket.
- Tighten the oil pan bolts to 9 ft-lbs (12 N.m) torque.

OIL PUMP INLET TUBE

Removal

- Remove the oil pump inlet tube mounting bolts. (FIG. 84)
- Remove the inlet tube.
- Remove the O-ring seal.

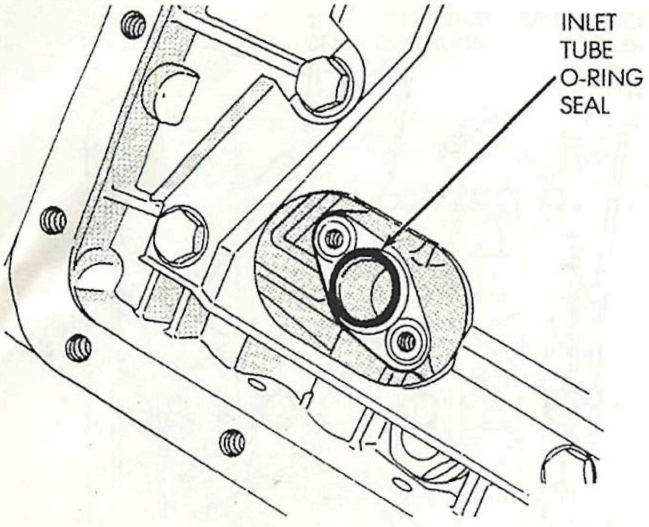
NOTE: *Never reuse the inlet tube O-ring seal. Always install a new seal when installing the inlet tube.*



(FIG. 84)

Installation

- Use a new inlet tube O-ring seal. Install inlet tube. (FIG. 85)
- Tighten inlet tube mounting bolts to 9 ft-lbs (12 N.m) torque.

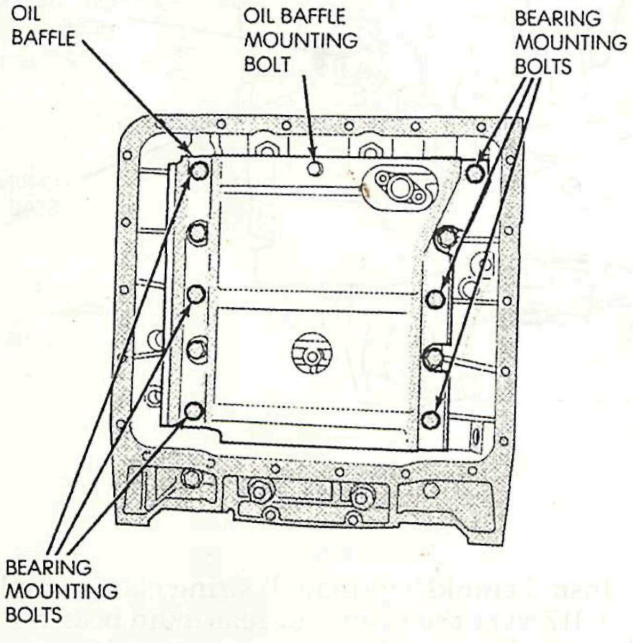


(FIG. 85)

OIL BAFFLE

Removal

- Remove the oil pan as outlined previously.
- Remove the oil baffle mounting bolts.
- Remove remaining bearing mounting bolts.
- Remove baffle. (FIG. 86)



(FIG. 86)

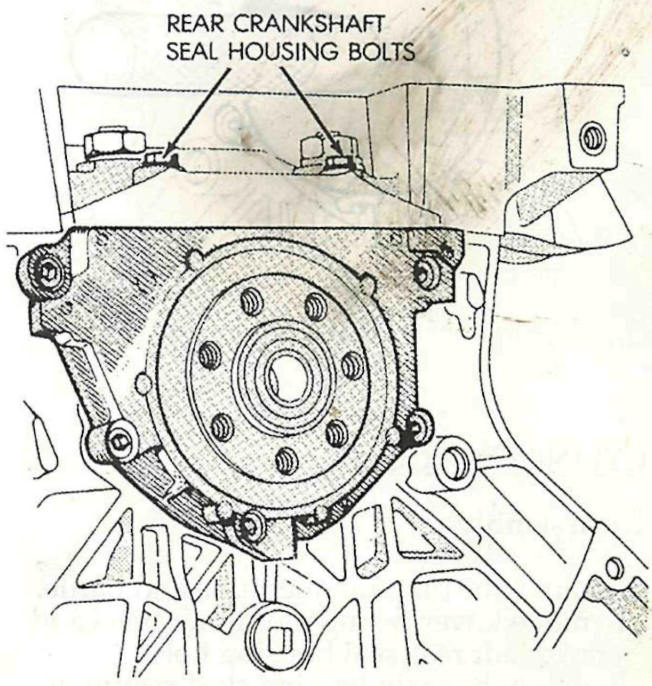
Installation

- Install baffle.
- Install and tighten mounting bolts to 13 ft-lbs (17.5 N.m) torque.
- Install and tighten the oil baffle mounting bolts to 9 ft-lbs (12.5 N.m) torque.

REAR CRANKSHAFT SEAL HOUSING

Removal

- Remove bolts from the lower casing.
- Remove seal housing mounting bolts.
- Remove seal housing and gasket. (FIG. 87)
- Remove old seal from the housing.



(FIG. 87)

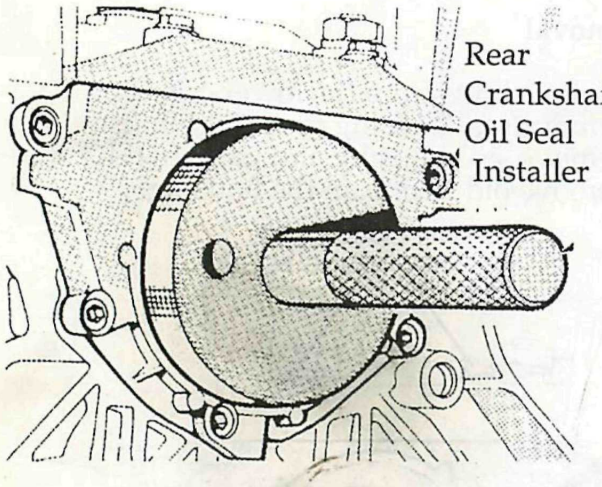
Installation

- Use a new gasket and install the seal housing to the cylinder block.
- Loosely install all bolts including the lower casing to seal housing bolts.

NOTE: *Tighten the seal housing block bolts first. Then tighten the lower casing to seal housing bolts.*

- Tighten the mounting bolts to 9 ft-lbs (12 N.m) torque.

- Lightly oil the inner and outer edges of the new seal.
- Place the new seal on seal installer tool # 7224. (FIG. 88)
- Install the new seal by gently tapping the end of tool number 7224 until the tool stops.
- Remove the seal installing tool by turning it while pulling it outward.



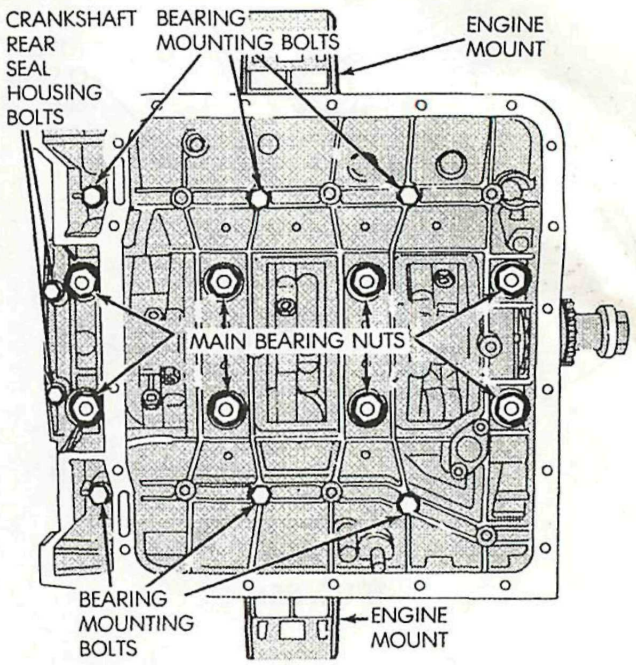
(FIG. 88)

CYLINDER BLOCK

Disassembly

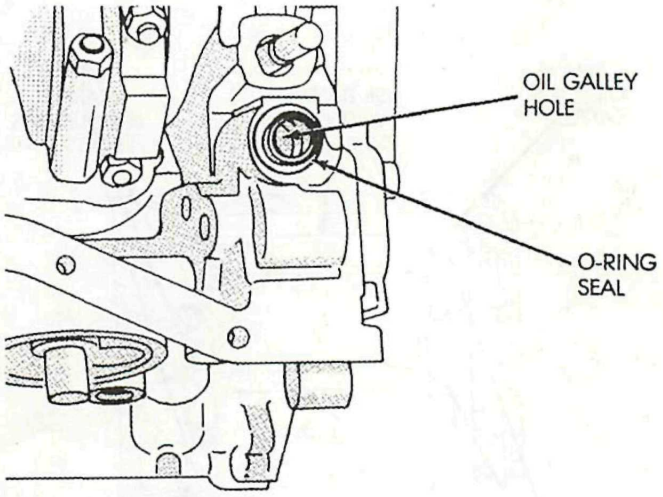
- Remove the oil pan, inlet tube and baffle.
- Remove lower casing mounting bolts and crankshaft rear seal housing bolts.
- Remove the main bearing stud retaining nuts. (FIG. 89)
- Using a soft hammer, tap the under side of the engine mounts to loosen the lower casing.
- Remove the lower casing.
- Remove and discard the oil galley O-ring seal. Never reuse the oil galley O-ring seal between the lower casing and the cylinder block. Install a new seal when the lower casing is installed.

CAUTION: *When cleaning the gasket surfaces, use a gasket remover to soften the old gasket material. Also, to avoid damage to the mating surfaces, do not use a metal scraper. Instead use a plastic or wooden scraper.*



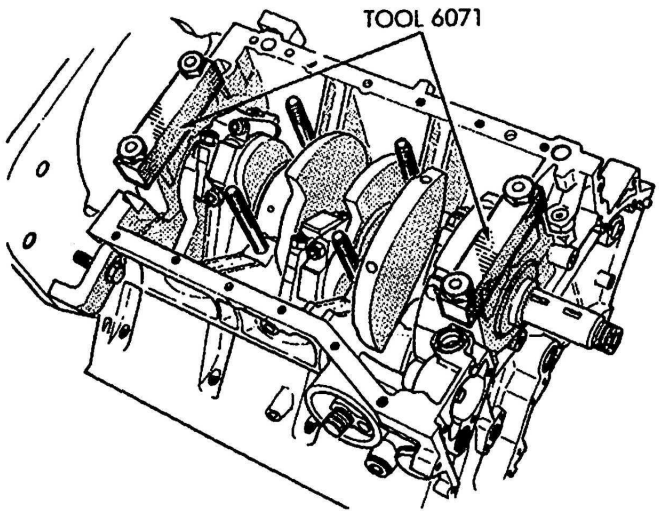
(FIG. 89)

- When cleaning, ensure that foreign material does not enter the oil galley hole in the cylinder block. (FIG. 90)



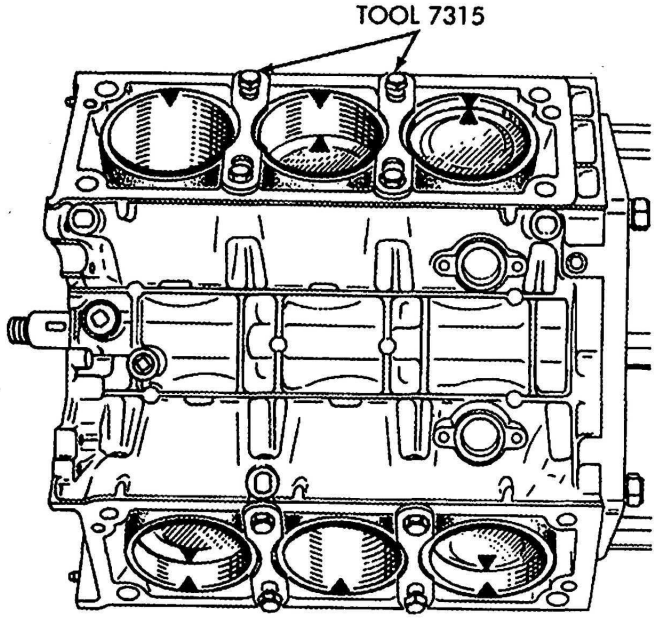
(FIG. 90)

- Install crankshaft main bearing clamps tool # 6017 over the front and rear main bearing caps. Use four lower casing retaining nuts to hold the clamps in position. (FIG. 91)



(FIG. 91)

- Turn the engine over on the engine stand and install liner clamp tool # 7315 to hold the piston-liner assembly in place. (FIG. 92)

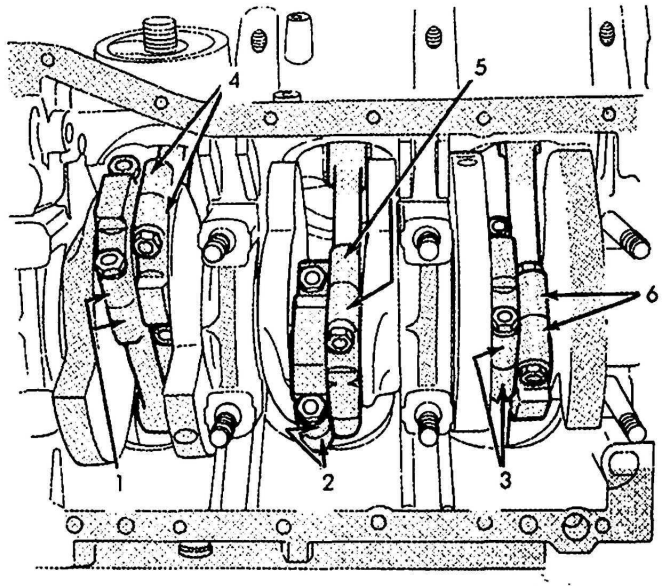


(FIG. 92)

- Turn the engine over on the engine stand.
- If the piston-liner assemblies will be reused, reference the piston to cylinder liner to cylin der block position using a grease pencil.

NOTE: *Connecting rod caps cannot be interchanged.*

- Mark each connecting rod and cap with the cylinder number on the side that faces out so that the caps can be installed with the proper connecting rods. (FIG. 93)



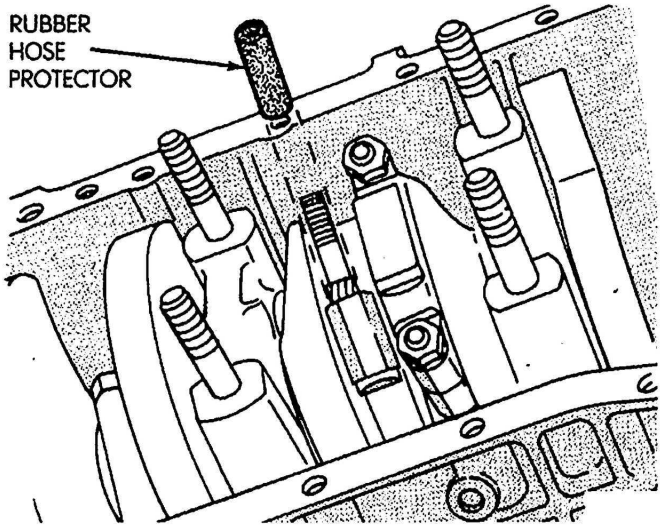
(FIG. 93)

NOTE: *When loosening the connecting rods nuts, loosen the nuts of both connecting rods at each journal before removing either one of the connecting rod-piston-liner assembly.*

- Loosen all connecting rod nuts. It will be necessary to rotate the crankshaft to provide access to all of the connecting rod nuts.

CAUTION: *When removing the piston-liner, care must be taken so that the connecting rod bolts do not nick the crankshaft journal. Make insulators out of rubber hose to fit over the connecting rod bolts once the cap is removed. Then remove the piston-liner assembly.* (FIG. 94)

- For each piston-liner assembly, turn the crankshaft until the connecting rod cap is at the bottom of its travel (piston at the bottom of the liner).



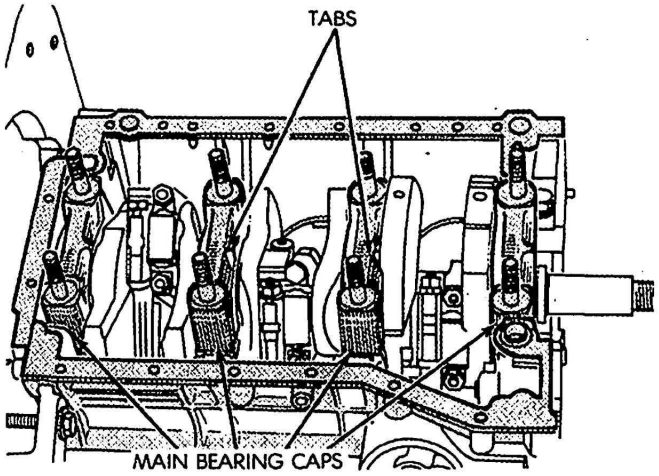
(FIG. 94)

- Remove the liner clamp tool # 7315 from the cylinder block.
- Have an assistant hold the liner assembly in place.
- Remove the connecting rod nuts and cap.
- Install rubber insulators over the connecting rod bolts. (FIG. 94)
- Remove the piston-liner assembly.
- Repeat this procedure an all other piston-liner assemblies that are to be removed.
- Remove and discard the liner seal.

NOTE: ***NEVER reuse the cylinder liner seals.***

- Remove the piston-connecting rod assembly from the bottom of the liner.
- Remove the oil pump from the front of the engine.
- Remove the main bearing clamp tool # 6017.

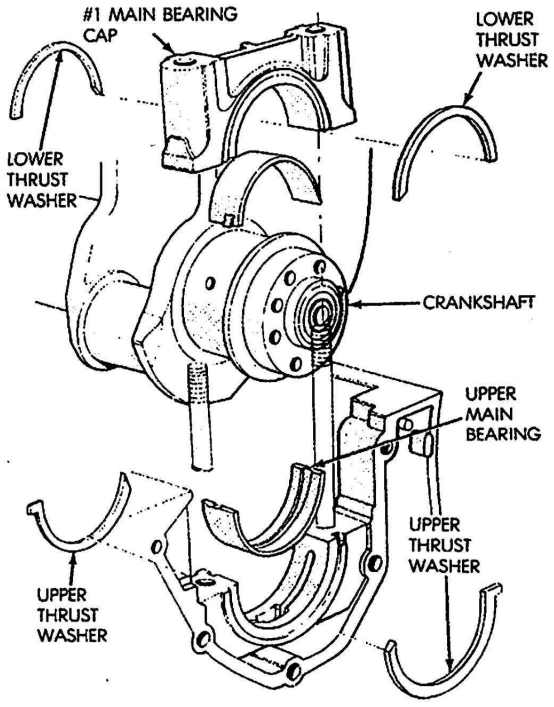
NOTE: *The main bearing caps are stamped one through four starting at the flywheel end of the engine. They MUST be installed in the correct order with the tabs pointing forward.* (FIG. 95)



(FIG 95)

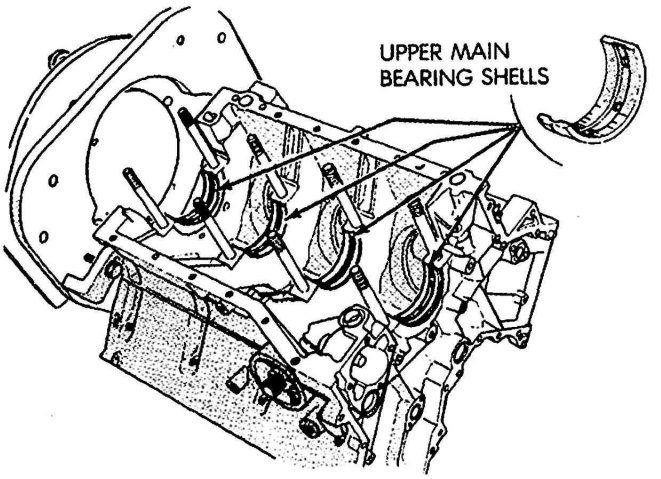
- Remove number one main bearing cap (fly wheel end of engine). Remove the thrust washer from the main cap.
- Remove the remaining main bearing caps.
- Lift the crankshaft out of the engine.
- Remove the upper thrust washers. (FIG. 96)

NOTE: *When removing the upper main bearing shells, mark the bearing number (1. 2. 3. and 4) on the back of the shell and keep it with the accompanying main bearing cap and lower bearing shell.*



(FIG. 96)

- Remove the upper main bearing shells. (FIG. 97)

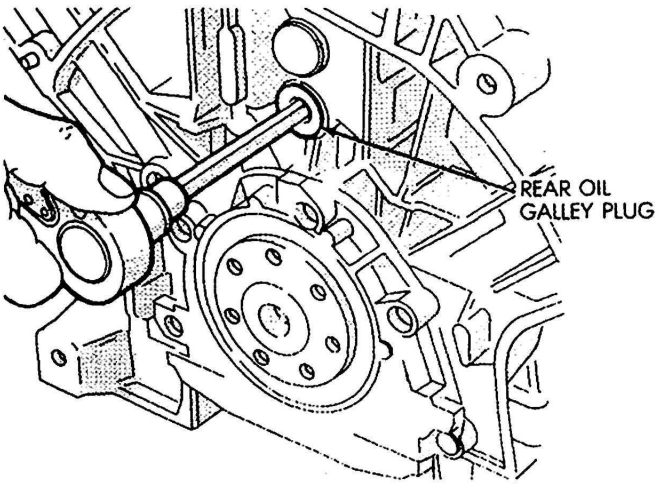


(FIG. 97)

Cleaning

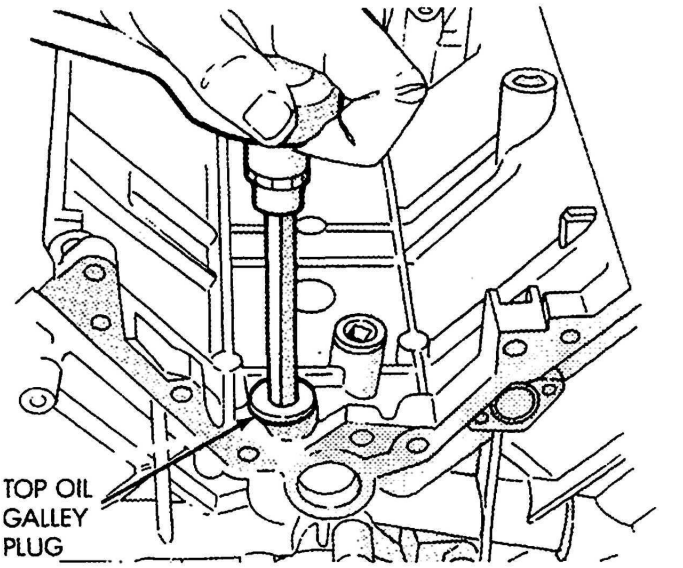
Clean the cylinder liner seat. Remove all deposits from the seat and from the water jacket walls of the cylinder.

when cleaning the cylinder block, use tool # 7399 (or equivalent) to remove the oil galley plug at the rear of the block. (FIG. 98)



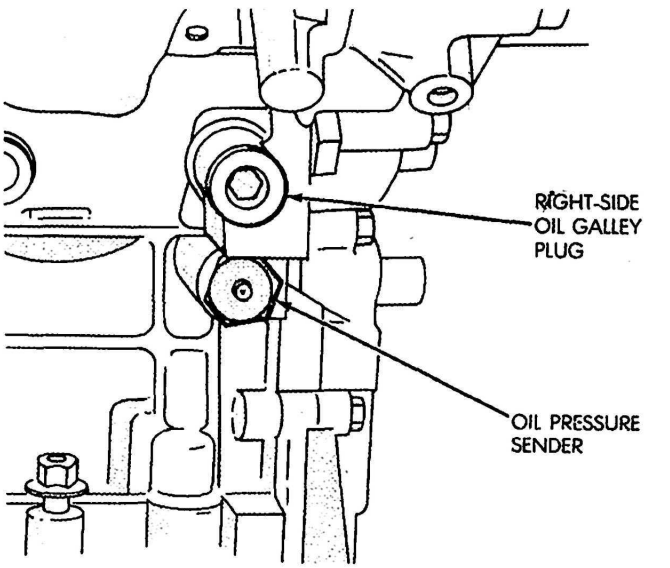
(FIG. 98)

- Remove oil galley plug on top of the block. (FIG. 99)



(FIG. 99)

- Remove oil galley plug on the right side of the cylinder block. (FIG. 100)



(FIG. 100)

- Remove the oil pressure sending unit. (FIG. 100).

- Spray compressed air into all oil galley pas sages to ensure they are clear of blockage. Refer to the General Information Section - Lubrication System.
- Use a gasket removal compound to soften the old gasket material. Use a wooden pr plastic scraper to remove the old gasket.
- Use fine grade 3M(TM) Scotch brite or equivalent to remove any small amounts of gasket material.
- Clean the oil passages in the crankshaft with a brush.

Inspection

Connecting Rods

The connecting rods are balanced assemblies with bearing inserts at the crankshaft journal end.

A squirt hole in the crankshaft end of the connecting rod provides lubrication for the cylinder walls and piston pins. The squirt hole faces the cylinder on on the other bank directly across from it when the connecting rod is installed correctly.

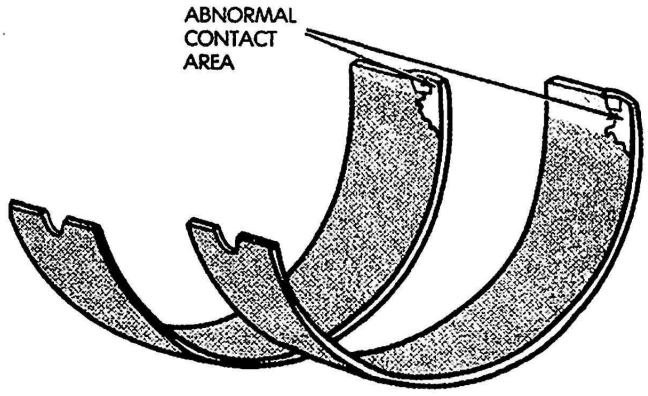
Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicate the probability of a misaligned connecting rod, inspect for correct rod alignment. Replace misaligned, bent or twisted rods.

Connecting Rod Bearings

Check the connecting rod bearing for scoring, flaking, scratches and excessive or abnormal wear patterns. The upper (thrust) bearing shell will have a larger wear pattern than the lower shell. If the bearing are scored, scratched or grooved, check the crankshaft connecting rod journal for scratches and nicks. Also check the oil passage from the main journal to the connecting rod journal for blockage. If the bearings are reused, they must be installed in the original position.

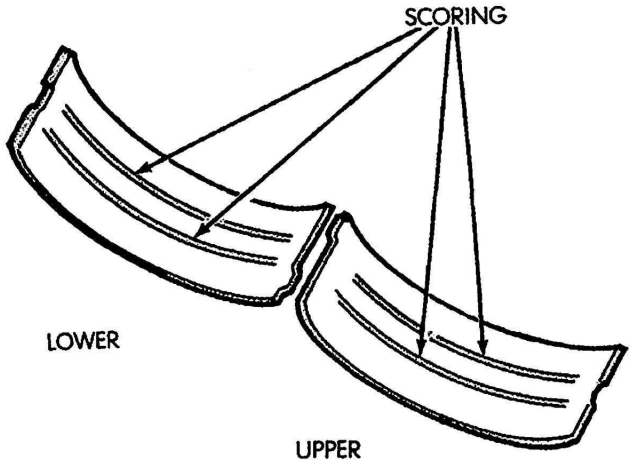
Rod Bearings

Check for abnormal contact area. This is caused by the locking tabs not fully seated or by being bent. (FIG. 101)



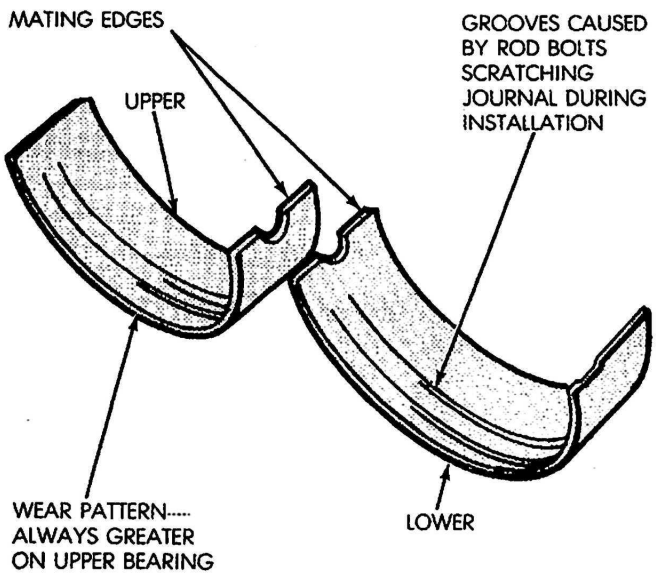
(FIG. 101)

Check for scoring. This is caused by insufficient lubrication. (FIG. 102)



(FIG. 102)

Check for grooves caused by rod bolts or dirt scratching the journal during installation. (FIG. 103)

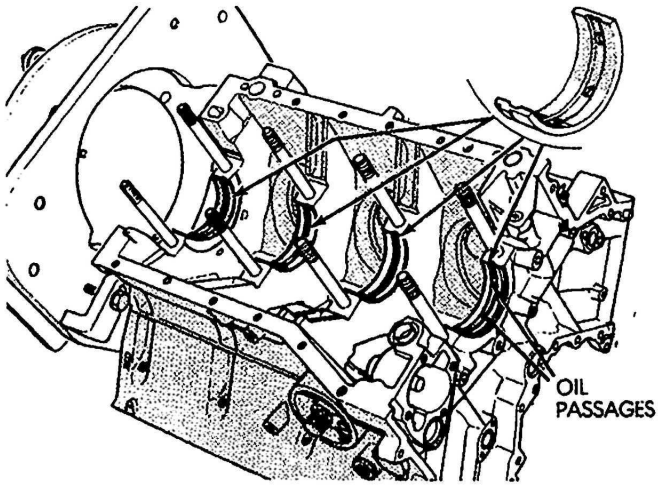


(FIG. 103)

Connecting rod bearings are available in one size only, 2.36 in. (59.97mm).

Main Bearings

Check the Main bearings for scoring, flaking, scratches and excessive or abnormal wear patterns. The lower bearing shell will have a larger wear pattern than the upper (grooved) shell. If the bearings are scored, scratched or grooved, check the crankshaft main bearing journals for scratches and nicks. Also check the oil passages in the cylinder block that feed the main bearings for blockage. (FIG. 104)



(FIG. 104)

Crankshaft

Check the oil passages from the main journals to the connecting rod journals for blockage. Check the journals for nicks and scratches. Polish and nick or scratches smooth.

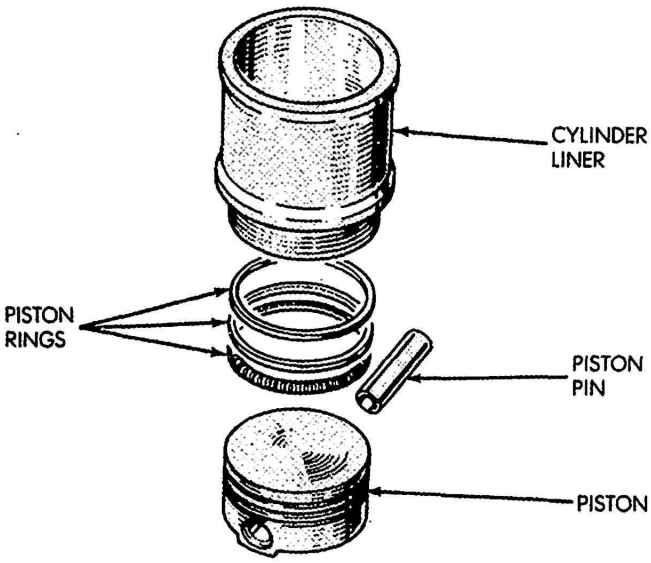
Main Bearings are available in one size only - 2.76 in. (70.06mm).

Oil Pump Bores

Check the oil pump bores in the cylinder block for scoring. If the bores are scored, the cylinder block and pump must be replaced.

CYLINDER LINER-PISTON-CONNECTING ROD

Kits containing cylinder liners, pistons, piston pins, and piston rings are available through the parts system. The components of these kits are pre-measured and matched to each other ensuring correct clearances. Each kit contains one of each component. (FIG. 105)



(FIG. 105)

CAUTION: *All parts of the kits are coated with a preservative that can be removed with Acetone. Do not scrap the coating off any component in the kit.*
Connecting rods are not part of the kits and are available separately.

Mark the components of each kit with the same letter so that they are not mixed with another kit. For Example: if six kits are used mark all components of the first kit with an A, the second kit with a B, etc...

If the old connecting rod(s) are to be reused, press the piston pins out (see Piston-Connecting Rod Section - Disassembly).

Liner Protrusion

When the cylinder liner and liner seal are installed into the cylinder block, the top of liner protrudes above the cylinder block deck.

On engines with engine number prior to # 89616, the protrusion specification is 0.0015 in. to 0.0078 in. (0.13mm to 0.20mm). It is preferred that the amount of protrusion be to the higher end of the tolerance 0.0078 in. (0.20mm).

On engines with engine number starting with # 89616, the protrusion specification is 0.0019 in. to 0.0047 in. (0.05mm to 0.12mm). It is preferred that the amount of protrusion be to the higher end of the tolerance 0.0047 in. (0.12mm).

NOTE: ***The new and old style liners are not interchangeable.***

The amount of protrusion is adjustable by using different thickness cylinder liner seals.

A steel cylinder liner seal is used to seal between the liner and the cylinder block.

Liner seals are available in 3 thicknesses, identified by **color code.**

COLOR CODE	THICKNESS
RED	0.004 in. (.10 mm)
SILVER	0.005 in. (.12 mm)
BLUE	0.006 in. (.15 mm)

NOTE: *When installing the liner seal into the cylinder liner, bend sizing tabs up towards the top of the liner.*

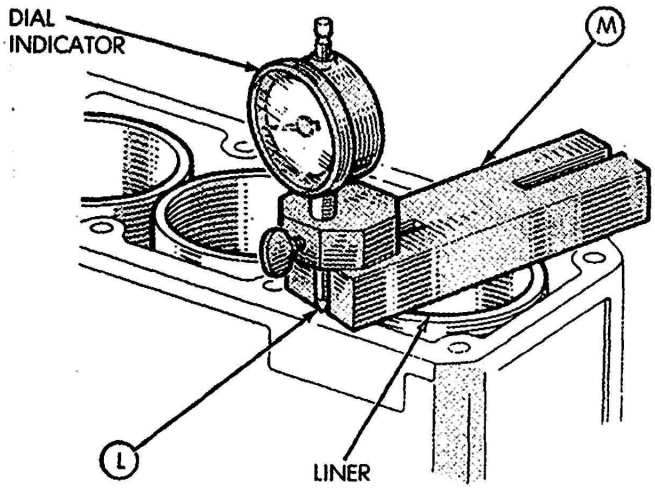
If the original cylinder liner-piston-connecting rod are being reused, position the liners in the same bore from which they were removed. Use a new liner seal of the same thickness as the discarded seal. Align the marks that were made on the cylinder block and liner when the engine was disassembled.

If new cylinder liner-piston assemblies are to be used, place the new liners with a two tabbed seal into the cylinder block. Since the liners are new, it is not necessary to place the liners in any particular order or turn the liner to any specific position when installing.

Check the liner protrusion using the support blocks tool #'s 6295 and 6296 and a dial gauge at the positions shown below. Liner protrusion specification is: **(FIG. 106)**

On engines with engine number prior to # 89616, the protrusion specification is 0.0015 in. to 0.0078 in. (0.13mm to 0.20mm). It is preferred that the amount of protrusion be to the higher end of the tolerance 0.0078 in. (0.20mm).

On engines with engine number starting with # 89616, the protrusion specification is 0.0019 in. to 0.0047 in. (0.05mm to 0.12mm). It is preferred that the amount of protrusion be to the higher end of the tolerance 0.0047 in. (0.12mm).

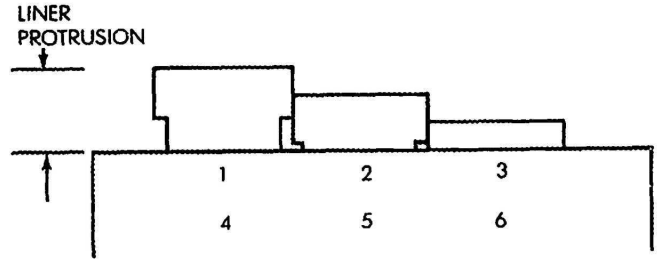


(FIG. 106)

The difference in protrusion between any two adjacent cylinder liners is not to exceed 0.0016 in. (0.04 mm) within a range of 0.0063 in and 0.0091 in (0.16 mm and 0.23 mm).

Adjust liner protrusion so that the amount of protrusion is greatest at the number one position on the left bank and the number four position on the right bank, and steps down in amounts to number 3 (left bank) or number 6 (right bank). Use different thickness liner seals as necessary. (FIG. 107)

Once the correct protrusions have been obtained, group the assemblies (kits) A, B, C, D, E, and F together and then number the cylinder liners, pistons and piston pins from 1 to 6 so that they match the corresponding connecting rod. If the original cylinder liner-piston-connecting rod assemblies are being reused, place the cylinder liner with the corresponding piston assembly.

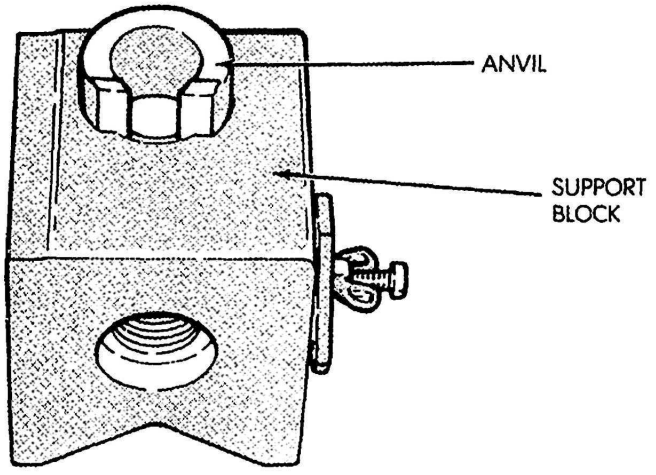


(FIG. 107)

PISTON-CONNECTING ROD

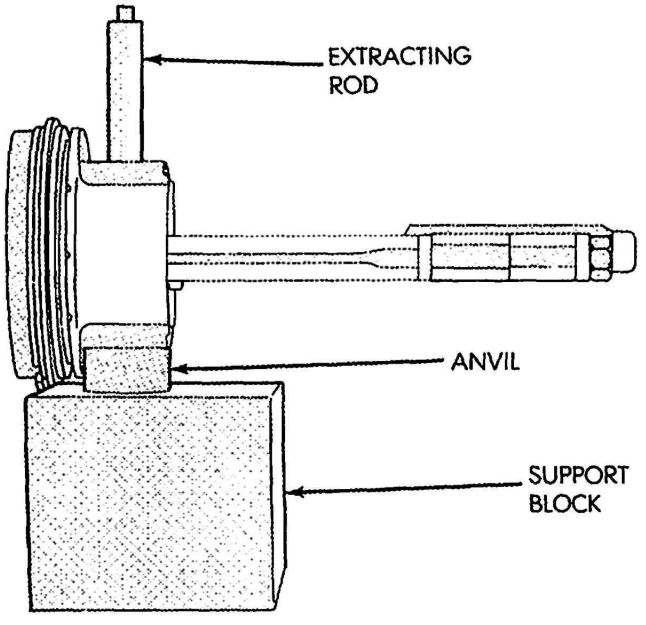
Disassembly

- Remove the piston connecting rod assembly from the cylinder liner by pulling it out the bottom of the liner.
- Use piston support block, anvil, and extractor rod from piston pin removal/installation kit tool #'s 7305 and 6137 to press the piston pin from the piston and connecting rod.
- Turn piston support block so that it rests on the "V" section. Place anvil into the top of the support. (FIG. 108)



(FIG. 108)

- Position the piston over the anvil and pilot the bottom edge of the pin into the anvil to center the piston. Install extracting rod into the top of the piston. Press the piston out of the connecting rod. (FIG. 109)



(FIG. 109)

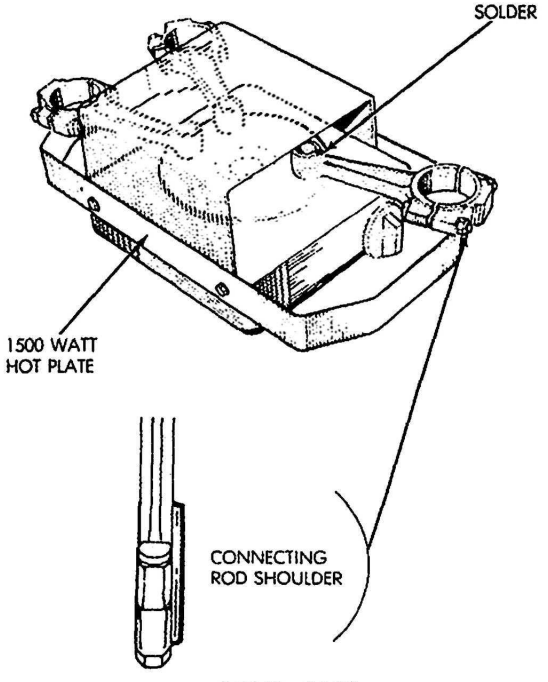
Assembly

- Check the connecting rods for twist or bend.
  - Maximum Twist - 0.002 in (0.051mm)
  - Maximum Bend - 0.003 in (0.076mm)
- Check the condition of the large end (crank shaft journal end). Use Arkansas smooth stone to remove any nicks and burrs that are found.
- Check the condition of the pin bore in the small end of the connecting rod. Use an oil stone to remove all nicks and burrs.
- Check the diameter of the pin bore. It must be between 0.9836 in and 0.9831 in (24.959 mm and 24.971 mm) to ensure the correct interference fit between the pin bore and the piston pin.

Pistons 1, 2 and 3 Left Bank

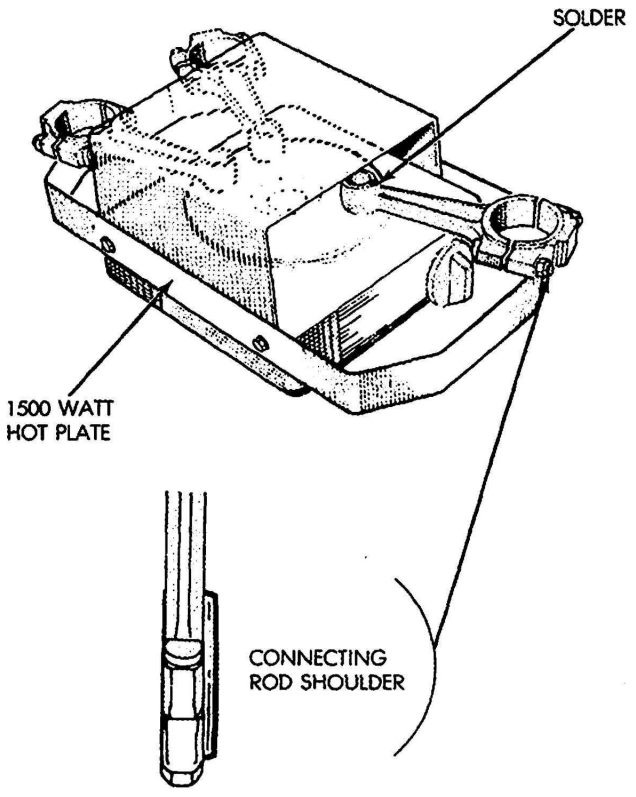
The piston, piston pin and connecting rod are assembled by heating the small end of the connecting rod until the piston pin bore expands. Slide the pin through the piston and the connecting rod. As the small end cools the pin bore contracts, forming an interference fit with the piston pin.

- Use a 1500 watt hot plate to heat the small end of the connecting rod. (FIG. 110).

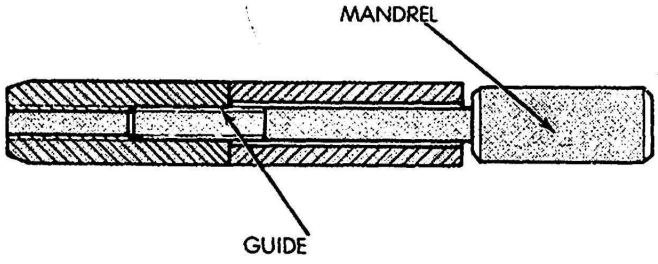


(FIG. 110)

- Place the small end of the connecting rods 1, 2 and 3 squarely on the hot plate with the shoulder of the large end towards the bottom.



- Use a small piece of solder with a melting point of 480° F. (250° C.) as a temperature guide. Place the solder on the small end of each connecting rod. (FIG. 110)
- Heat up the connecting rod small ends until the solder liquefies.
- Insert the piston pin into the pin bore of the piston. It should rotate freely.
- Use a Mandrel A-8 and Guide C-9 from piston pin removal/installation tool kit # 7305 to install the piston pin. (FIG. 111)



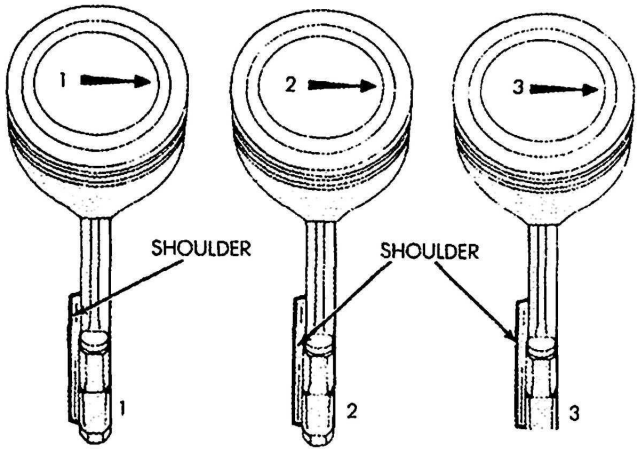
(FIG. 111)

- Position the piston pin in between the man drel and the guide. Do not tighten the man drel, back it off one turn from the piston pin so that the pin floats freely between the mandrel and the guide.

NOTES:

- Lubricate the guide and piston pin with clean engine oil.

NOTE: *When assembling the left bank pistons #'s 1, 2 and 3, the shoulder on the connecting rod large end must be opposite the arrow on the piston crown.* (FIG. 112)

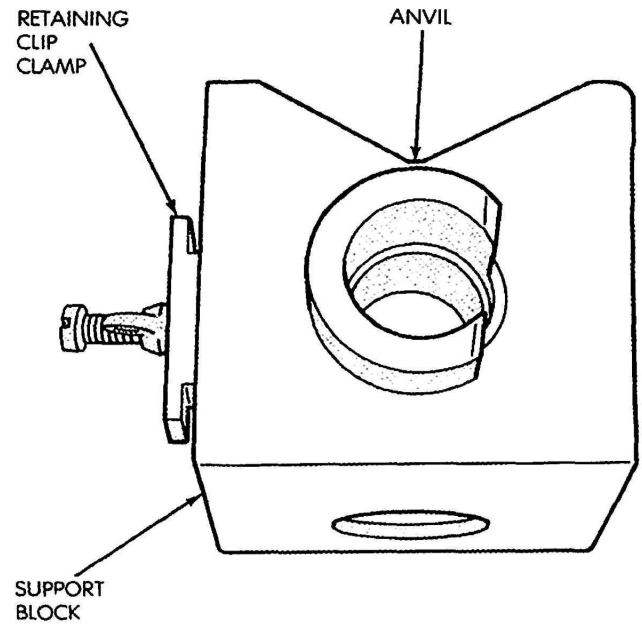


(FIG. 112)

- From the Piston Pin removal/installation tool # 7305, place the correct anvil on top of the support block with the flat side opposite the retaining clip clamp.

- Clamp the piston, to the support block with the arrow on the piston crown pointing up . (FIG. 113)
- To center the piston to the anvil, Slide the mandrel-piston pin-guide through the piston and the anvil. This will align the pin bore and anvil. Lightly tighten the clip. Pull the mandrel- piston pin-guide assembly up and out of the piston.

NOTE: *The following procedure must be performed as quickly as possible to prevent the connecting rod small end from cooling and contracting before the piston pin is completely installed.*

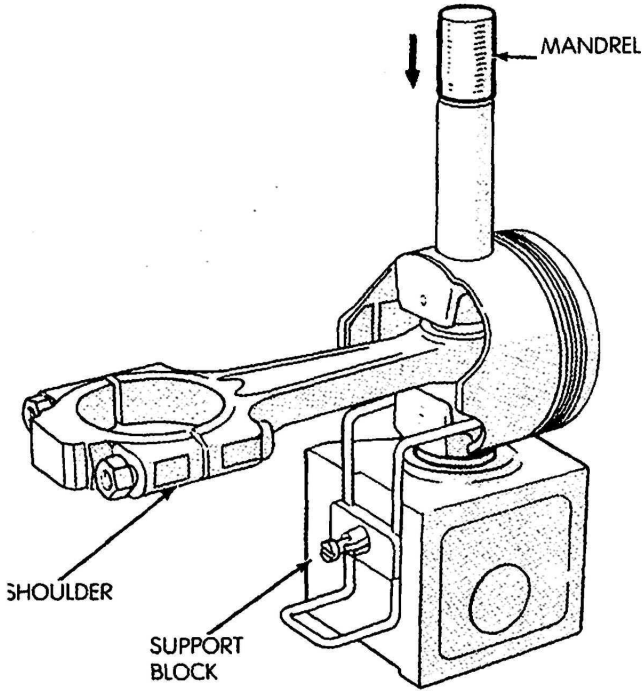


(FIG 113)

- Ensure that the solder is liquefied on the small end of the connecting rod.

NOTE: *When assembling the connecting rods for cylinders 1, 2 and 3, the piston must be clamped in place on the support block with the arrow on the piston crown pointing up and the connecting rod installed with the shoulder pointing down (opposite the arrow on the piston).*

- Wipe the solder from the small end of the connecting rod.
- Insert the guide end of the mandrel-piston pin-guide assembly A-8 into the top of the piston pin bore (but not down to the center of the piston).
- Using one hand, remove the connecting rod from the hot plate and , with the shoulder pointing down, insert the connecting rod into the piston on the support block.
- With the other hand, quickly press the man drel-piston pin-guide assembly down until the guide bottoms in the support bracket.
- Wait 10 seconds and then remove the con necting rod-piston assembly from the sup port block. Unscrew the guide and remove the mandrel (A-8). (FIG. 114)



(FIG. 114)

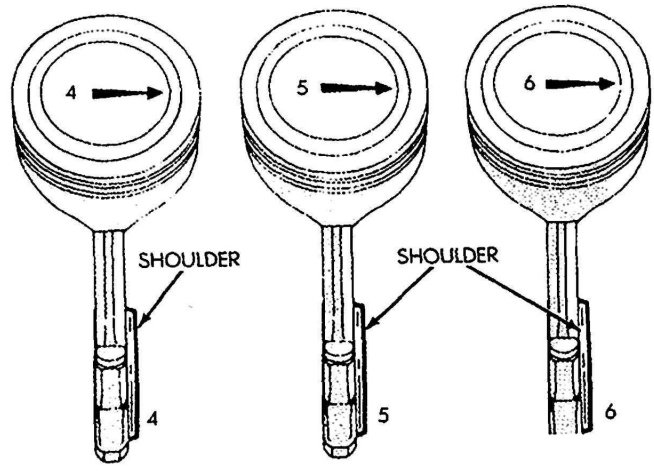
- Check that the connecting rod and piston pin are centered to the piston.
- Assemble the other two piston-connecting rods in the same manner.

Pistons 4, 5 and 6 - Right Bank

- Place the small ends of the connecting rods 4, 5 and 6 squarely onto the hot plate with the shoulder on the large end pointing up.
- Place the piston on the support block with the arrow in the piston crown pointing up.

NOTE: *When installing the the right bank pistons (4, 5 and 6), the shoulder on the connecting rod large end must be on the same side as the arrow on the piston crown.*

- Assemble the piston-connecting rods as described for the left bank except, insert the connecting rods into the piston with the shoulder pointing up. (FIG. 115)



(FIG. 115)

PISTON RINGS

Replacement

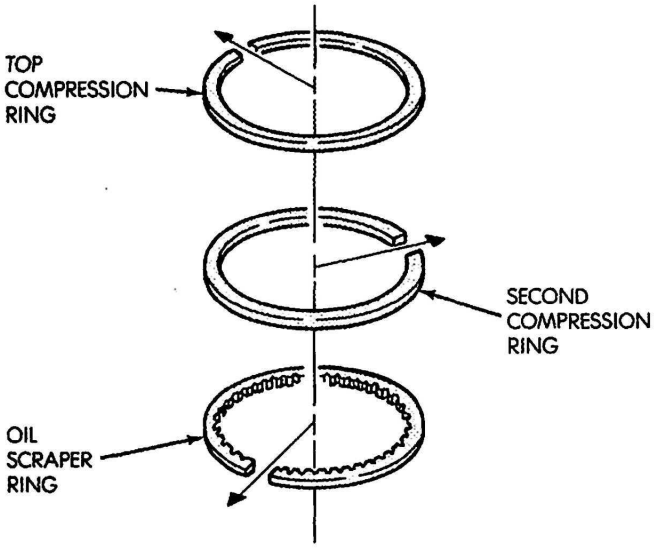
NOTE: *The piston ring end gap has been preset to the cylinder liner. There is no need to trim the ring ends.*

The scraping edge of the top compression ring is not tapered and can be installed with either side up.

The scraping edge of the second compression ring is tapered and MUST be installed with the side marked "Top" facing up.

The oil scraper ring is a U-flex design and can be installed with either side up.

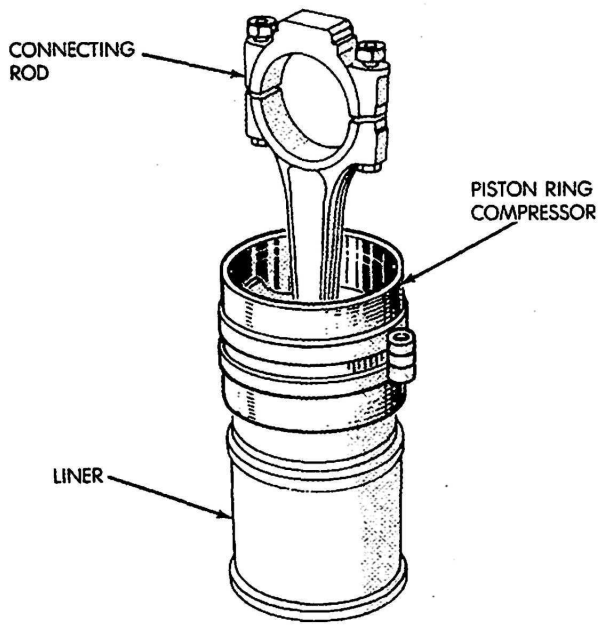
- Install the rings with each end gap 120° apart from each other. (FIG. 116)



(FIG. 116)

CAUTION: *The top of the cylinder liner is not chamfered. Do not install the piston from the top of the liner because damage to the piston rings and ring lands can occur. The piston MUST be installed from the bottom of the liner.*

- Lubricate the piston, piston pin and cylinder liner with clean engine oil.
- Use a piston ring compressor and install the piston into the cylinder liner from the bottom. (FIG. 117)
- Install the connecting rod bearings.



(FIG. 117)

CAUTION: *When installing the piston liner assembly into the cylinder block, slide insulators made from rubber hose over the ends of the connecting rod bolts to prevent nicking the crankshaft journals.*

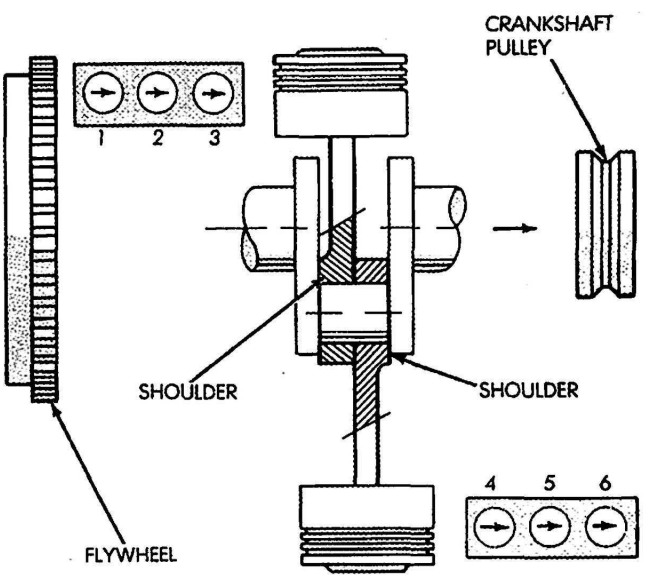
- Turn the crankshaft so that the connecting rod journal of the cylinder to be installed is at the bottom of its stroke and centered to the liner bore of the cylinder block.

NOTE: *If original cylinder liner and pistons are being reused, be sure to align the marks that were made on both the liner and the piston during disassembly.*

- Install cylinder liner-piston assemblies 1, 2 and 3 on the left bank of the engine with the arrow on the crown of the piston pointing toward the crankshaft pulley end and the shoulder of the connecting rod pointing to the flywheel end of the engine. (FIG. 118)

NOTE: *Do not tighten the connecting rod nuts until all cylinder liner-piston assemblies are installed.*

- Install the connecting rod cap and finger tighten the connecting rod nuts. Do not tighten the nuts at this time.
- Use liner clamp tool # 7315 to hold the liners in place before installing the next assembly.



(FIG. 118)

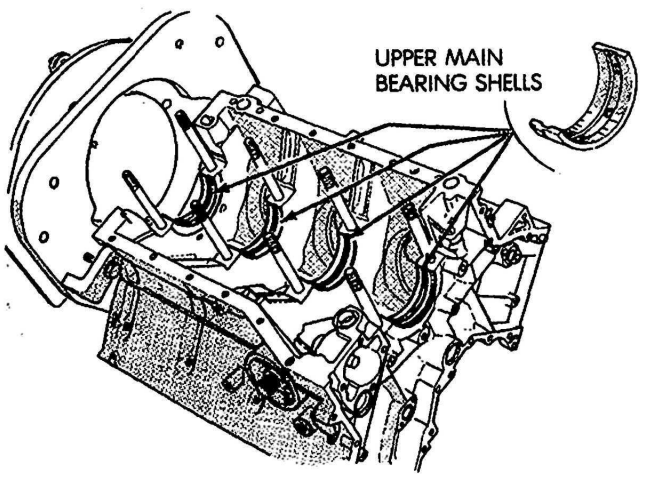
- Install cylinder liner-piston assemblies 4, 5 and 6 on the right bank of the engine with both the arrows on the crown of the piston and shoulder of the connecting rod facing the crankshaft pulley end of the engine.
- Tighten all of the connecting rod nuts to 33 ft-lbs (47.5 N.m) torque.
- Using a feeler gauge or a magnetic base dial indicator, check the connecting rod side clearance at each journal. The side clearance must be between 0.008 in and 0.015 in (0.20mm and 0.38mm).

CYLINDER BLOCK

Assembly

NOTE: *When assembling the cylinder block, the O-ring seals for the lower casing and oil pump inlet tube MUST be replaced, Also replace the oil galley plug gaskets (washers).*

- Install the oil galley plugs with new gaskets.
- Check that the cylinder head bolts thread in and out of the bolt holes easily. It may be necessary to clean the threads.
- The upper Main bearing shells have an oil groove down the middle. Install them with the locating tabs on the back of the bearings positioned in the locating grooves of the cyl inder block. (FIG. 119)



(FIG. 119)

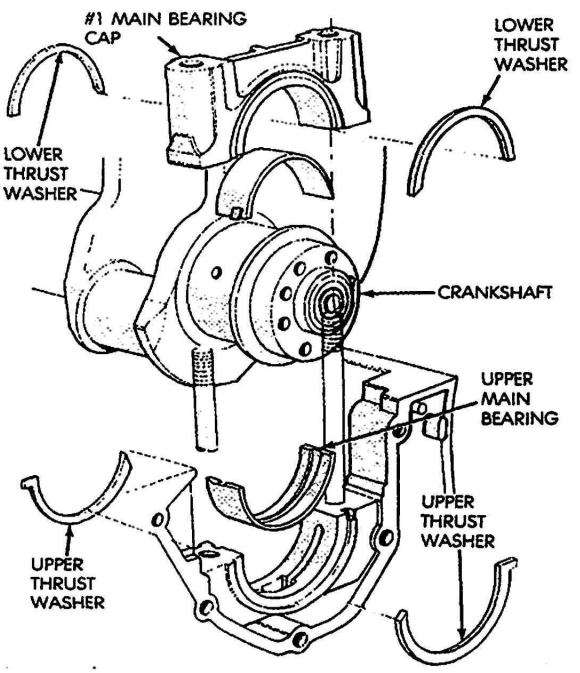
- The lower main bearing shells are not grooved. Install them into the main bearing caps.
- Thrust bearings are available as kits in four different sizes:

  - - 0.091 - 0.093 in (2.30 - 2.35 mm)
  - - 0.094 - 0.096 in (2.40 - 2.45 mm)
  - - 0.096 - 0.098 in (2.45 - 2.50 mm)
  - - 0.098 - 0.100 in (2.50 - 2.55 mm)

NOTE: *Install new thrust bearing halves with the oil grooves facing out towards the thrust flanges of the crankshaft.*

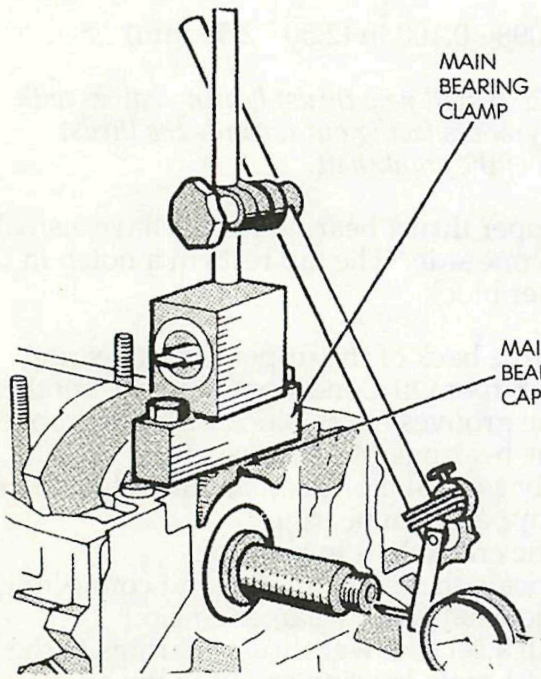
The upper thrust bearing halves have a small tab on one side. The tap rests in a notch in the cylinder block.

- Coat the back of the upper thrust bearing with Super Oil Conditioner and install them to the grooves in the block. The oil groove in the bearings **MUST** face out.
- Apply a coating of clean engine oil to all of the upper main bearings.
- Set the crankshaft in position.
- Lubricate the main bearing and connecting rod journals with clean engine oil.
- Install a set of lower thrust bearings to the rear #1 main bearing cap with the oil grooves facing out. (FIG. 120)



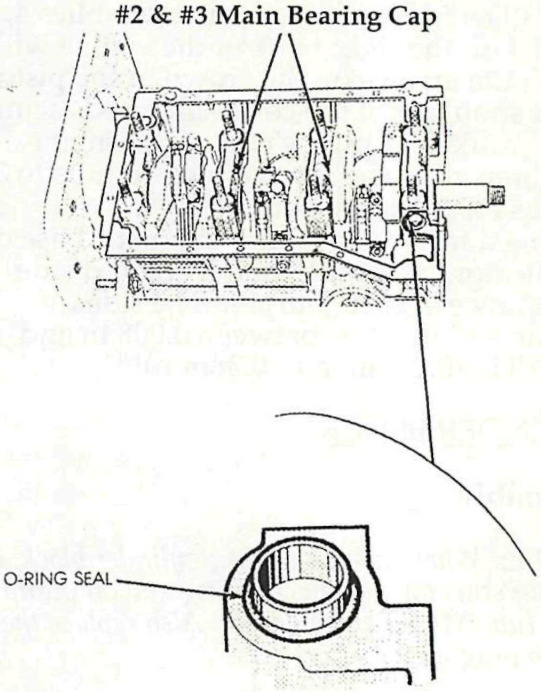
(FIG. 120)

- Install the front and rear main bearing caps with the tabs facing the crankshaft pulley end of the engine. (FIG. 121)
- Install the main bearing clamps (tool # 6017) over the main bearing caps. Use four of the lower casing mounting nuts to hold them in place. Tighten the nuts to 20 ft-lbs (30 N.m) torque. (FIG. 121)



(FIG. 121)

- Place a magnetic base dial indicator onto the front main bearing clamp tool # 6017. Position the gauge against the front end of the crankshaft. (FIG. 121)
- With the crankshaft pushed towards the flywheel end of the block, set the gauge to zero.
- Push the crankshaft towards the crankshaft pulley end of the block until it stops.
- Check the amount of end play indicated on the dial. It should be between 0.003 in and 0.011 in (0.07 mm and 0.27 mm).
- If the endplay is not within this range use thrust bearings of a different thickness until the correct end play is obtained.
- Install the crankshaft turning tool # 6072.
- Remove the main bearing cap clamp tool # 6071.
- Install #2 and #3 main bearing caps with the tabs pointing forward.
- Install new O-ring seal on the oil pump entry tube. (FIG. 122)

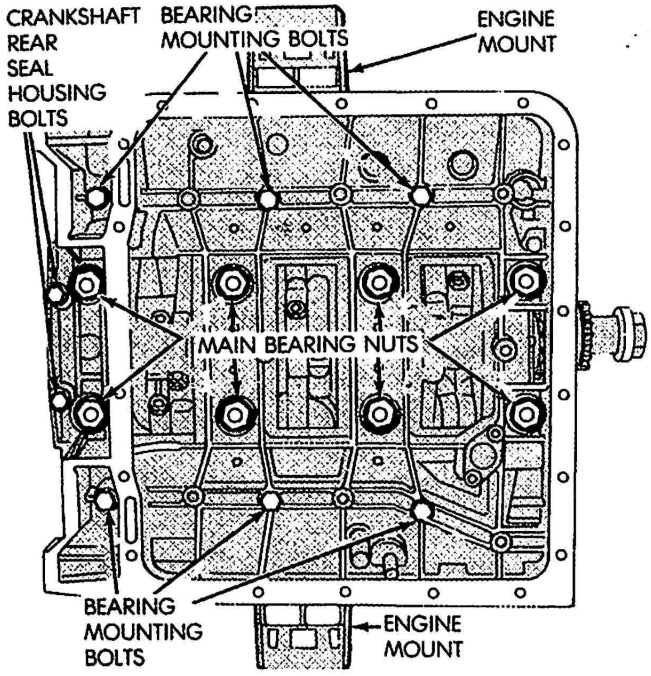


(FIG. 122)

- Install the crankshaft rear seal housing with a new gasket. Install two mounting bolts finger tight to keep the rear seal housing in position.

NOTE: *When installing the lower casing, alignment plate tool # 6140 MUST be used. Use of the alignment plate will ensure correct positioning of the lower casing and will avoid distortion to the convertor housing of the transmission.*

- Apply a bead of RTV sealer to the mating surface of the cylinder block.
- Place the lower casing over the cylinder block and install the flat washers. Start threading the retaining nuts on the studs, but do not tighten them at this time.
- Insert the lower casing bolts into the holes, but do not tighten.
- Insert the lower casing to rear seal housing bolts into the bolt holes, but do not tighten them. (FIG. 123)

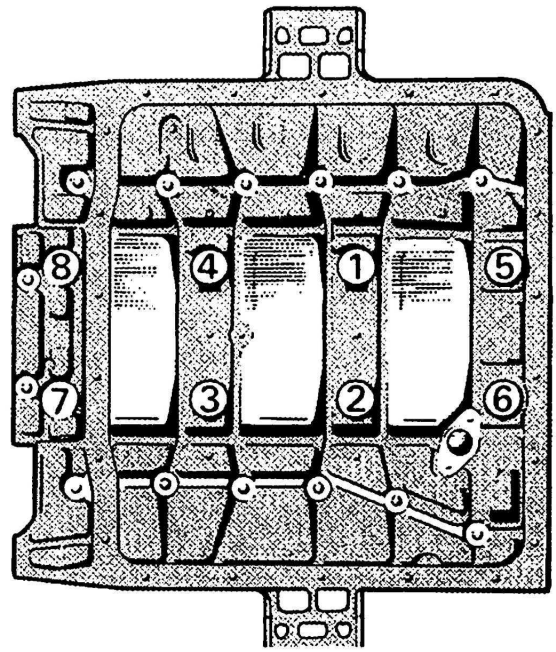


(FIG. 123)

- Push the lower casing forward and using the bolts supplied, attach the lower casing alignment plate tool # 6140 with the machined bosses on the plate facing the rear of the engine. The bolts thread into the rear crank shaft seal housing mounting bolt holes. Slightly tighten the bolts.

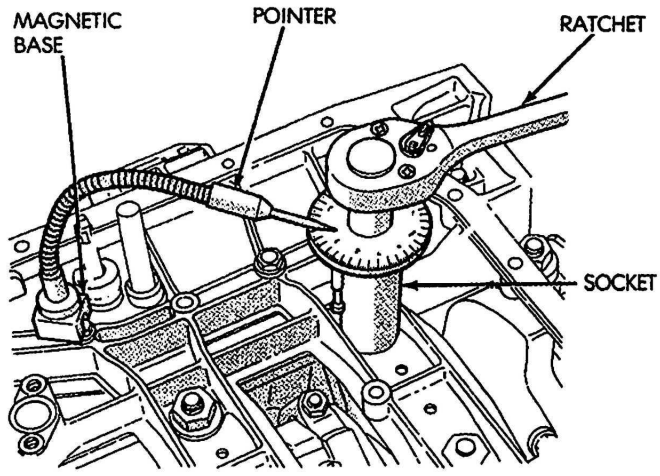
- Pull the lower casing back against the alignment plate then proceed with tightening the lower casing nuts.

- Pretighten the nuts in sequence shown start ing with # 1 and proceeding in sequence to 20 ft-lbs (30 N.m) torque. (FIG. 124)



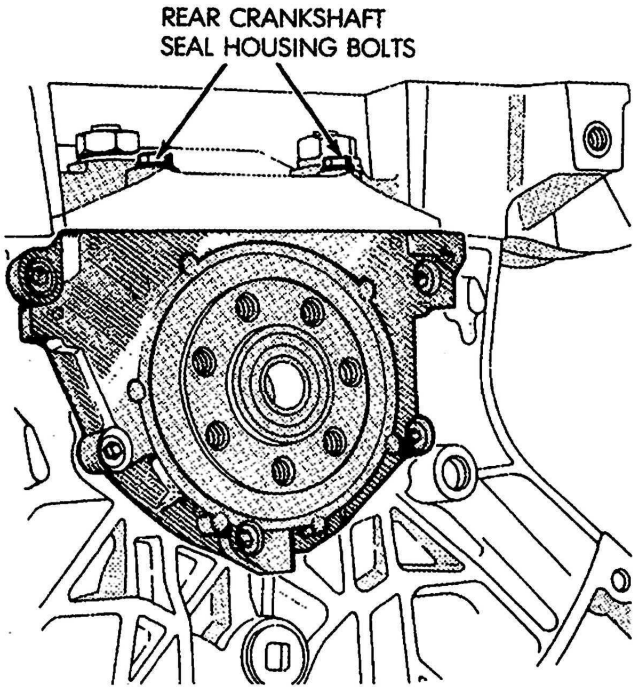
(FIG. 124)

- - Attach angular wrench tool # 7321 between a socket and a ratchet. (FIG. 125)
- - Turn the angular wrench until the locking arm rests against a solid object.
- - Attach magnetic base of pointer to an other nut or bolt. (FIG. 125)
- - Position the end of the pointer so that it is aligned with the 75° mark on the angular wrench.
- - Tighten the nuts until the zero on the dial align with the end of the pointer. (FIG. 125)



(FIG. 125)

- Repeat the angular tightening, in sequence, for the remaining nuts.
- Remove the alignment plate tool # 6140.
- Tighten the lower casing to rear crankshaft seal housing bolts to 9 ft-lbs (12 N.m) torque. (FIG. 126)

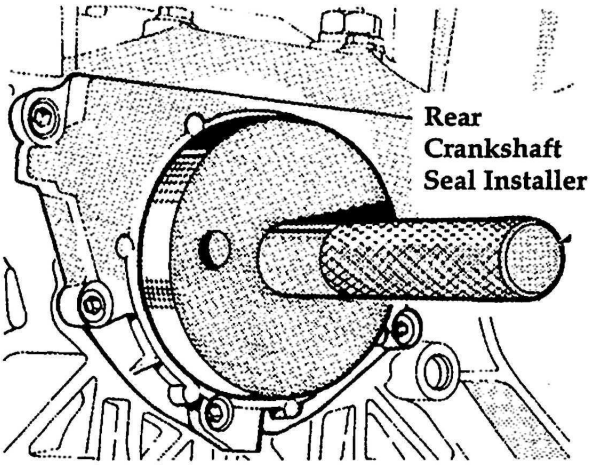


(FIG. 126)

- Install the remaining seal housing bolts and tighten them to 9 ft-lbs (12N.m) torque.
- Tighten the lower casing bolts to 13 ft-lbs (17.5 N.m) torque.
- Install a new rear crankshaft oil seal using the rear crankshaft seal installation tool #7224 (for the old seal) or tool # 6482 (for the new seal). Lubricate the seal prior to installing it.

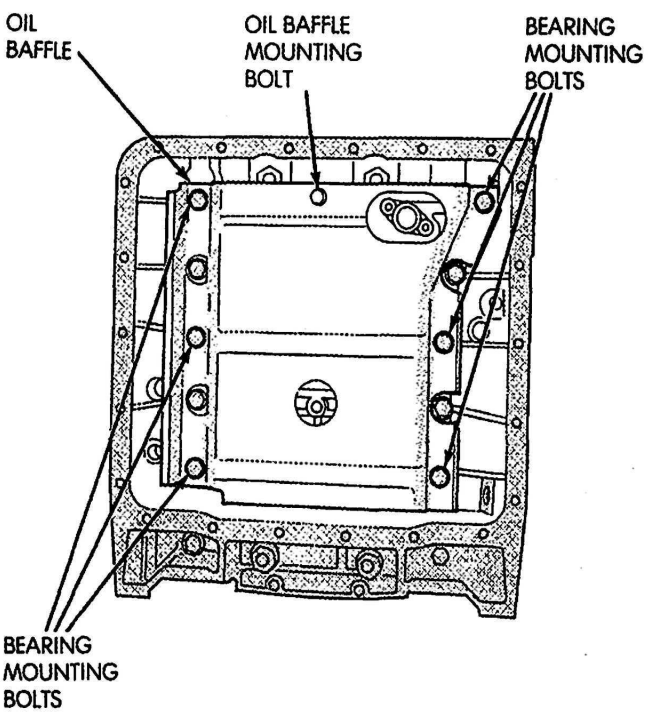
NOTE: *There was a rear crankshaft seal change on engines starting with engine number 89616. The new seal can be interchanged between the engine numbers, but must be installed with the correct installation tool when being replaced.*

- Gently tap the seal into place until the installer stops.
- Remove the installer by turning and pulling it at the same time. (FIG. 127)



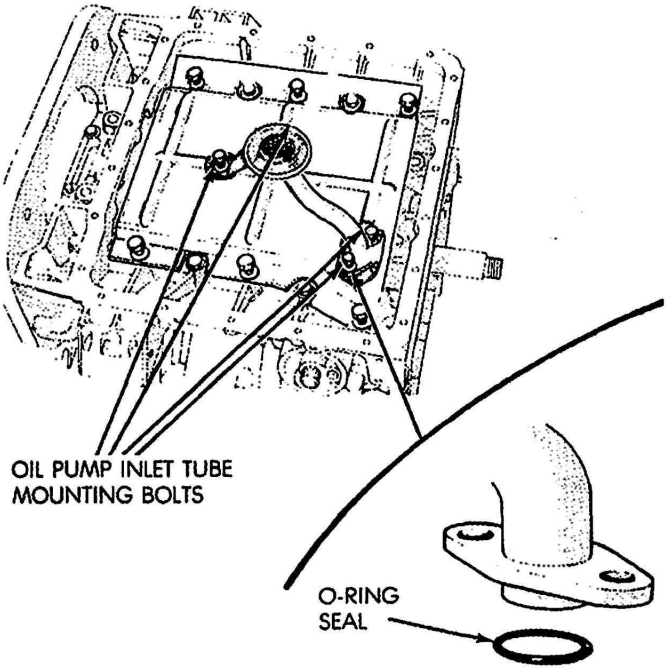
(FIG. 127)

- Install the oil baffle. Tighten bolt (G) to 9 ft-lbs (12.5 N.m) torque. Tighten bolts (H) to 13 ft-lbs (17.5 N.m) torque. (FIG. 128)



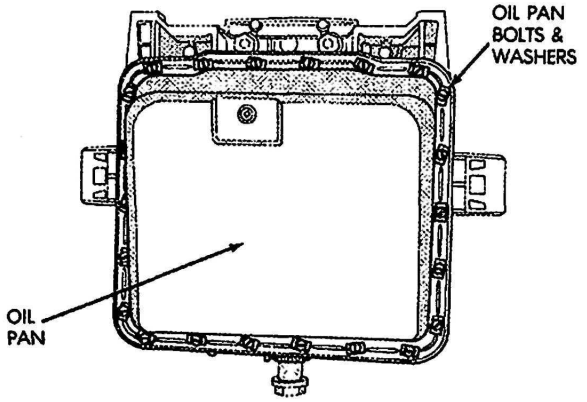
(FIG. 128)

- Install a new O-ring seal on the bottom of the oil pump inlet tube. (FIG. 129)
- Install the oil pump inlet tube. Tighten mounting bolts to 9 ft-lbs (12.5 N.m) torque.
- Install dry, a new oil pan gasket to the lower casing.



(FIG. 129)

- Install the oil pan. Tighten the mounting bolts to 9 ft-lbs (12.5 N.m) torque.
- Install the oil pan drain plug using a new gasket (washer). Tighten the plug to 22 ft-lbs (30 N.m) torque. (FIG. 130)



(FIG. 130)

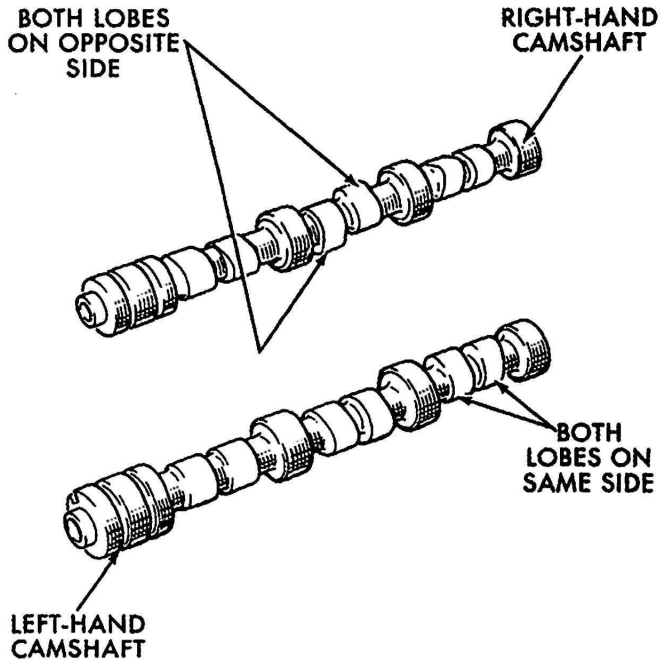
CAMSHAFT

Installation

- The right and left hand camshafts are not the same and cannot be interchanged. The cam shafts can be identified by the location of the lobes. (FIG. 131)

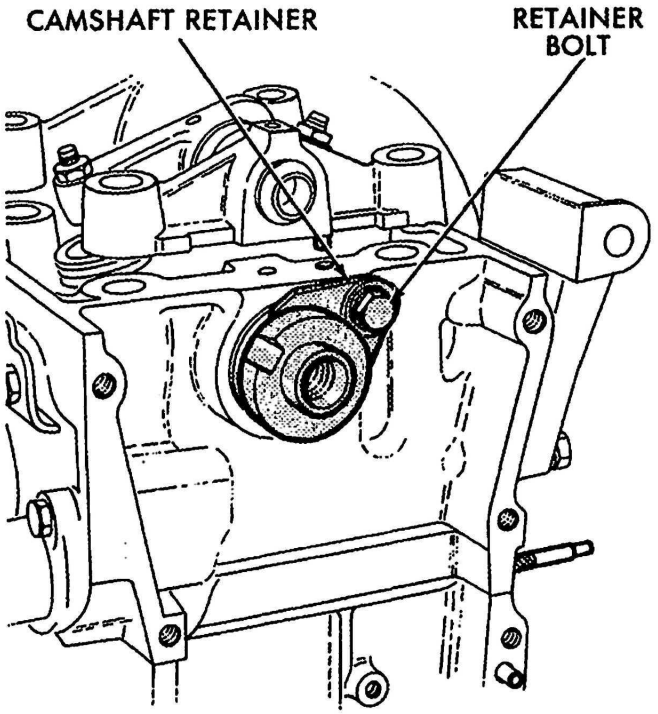
On the left hand camshaft, both lobes of each cylinder are on the same side.

On the right hand camshaft, the lobes of each cylinder are on opposite sides.



(FIG. 131)

- Lubricate the camshaft journals with Super Oil Conditioner.
- Install the camshaft from the rear of the cylinder head.
- Slide retainer into the groove at the front of the camshaft. (FIG. 132)



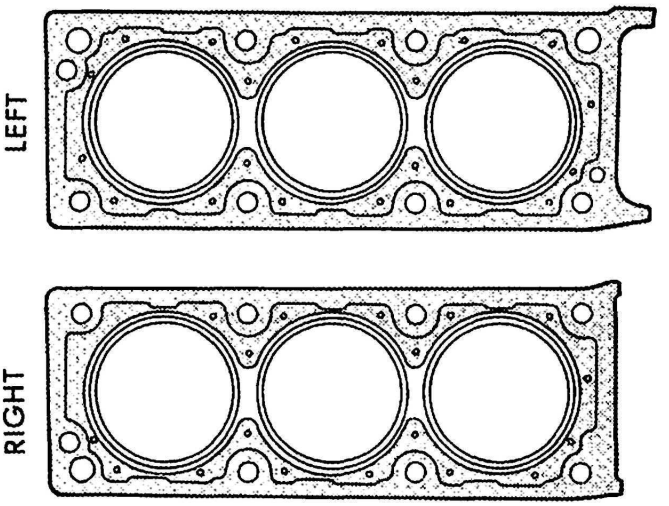
(FIG. 132)

- Tighten bolt to 9 ft-lbs (12 N.m) torque.
- Check the camshaft end play using a feeler gauge or a dial indicator.
- Push the camshaft to the front. Insert feeler gauge between the retainer and the front of the camshaft. Select a feeler gauge that drags as it is pulled through. The end play must be between 0.003 in and 0.055 in (0.07mm and 0.14 mm).
- Install the cover with a new gasket at the rear of the cylinder head. Coat the mount ing bolt threads with Loctite 271 and tighten them to 48 in-lbs (6 N.m) torque.

CYLINDER HEAD

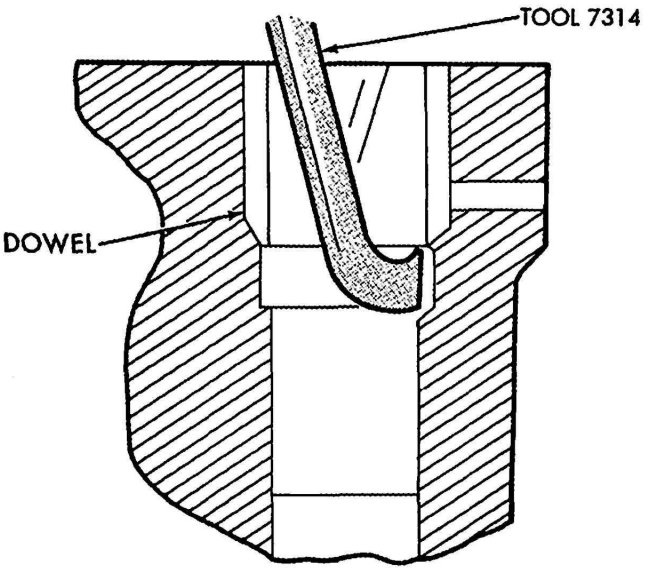
Installation

NOTE: *The cylinder head gaskets are not identical. The left hand gasket has a larger cut out at the front than the right hand gasket. Also engines starting with engine number 89616 utilize a different gasket that is not interchangeable with engines with engine numbers prior to 89616.* (FIG. 133)



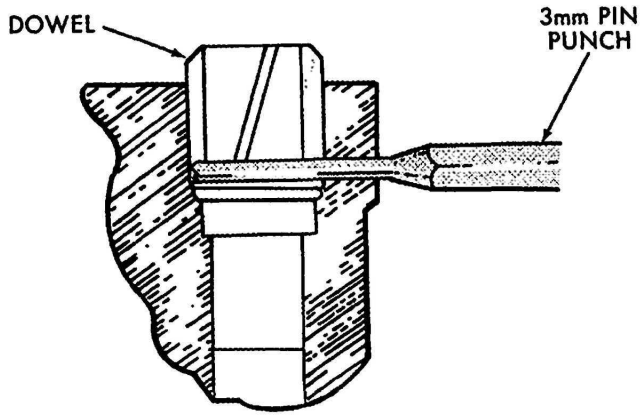
(FIG. 133)

- Pull the cylinder head dowels up using dowel extractor tool # 7314. (FIG. 134)



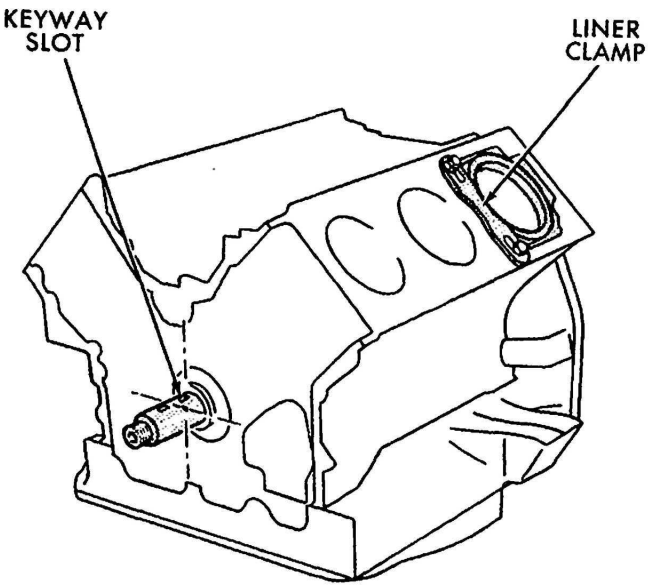
(FIG. 134)

- Install 3mm pin punches into the holes in the block below the locating dowel. Push the dowels down until they contact the pin punches. (FIG. 135)



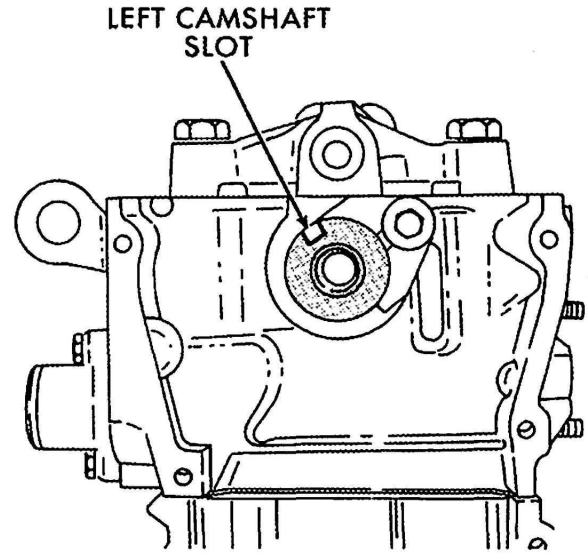
(FIG. 135)

- Rotate the crankshaft until the keyway slot is pointing straight up. This will position the number 1 piston below top dead center (TDC) and prevent contact between pistons and valves. (FIG. 136)
- Remove the cylinder liner clamps from the left cylinder head. (FIG. 136)



(FIG. 136)

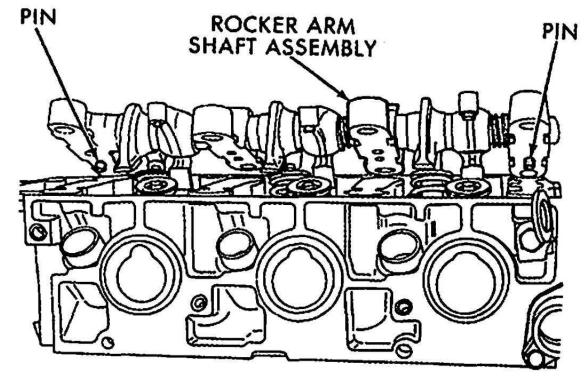
- Install dry, a new cylinder head gasket to the left cylinder bank.
- Turn the engine on the engine stand until the left bank is pointing straight up.
- Position the left cylinder head over the new head gasket.
- Turn the left camshaft until the slot in the front is positioned as shown. (fig. 137)



(FIG. 137)

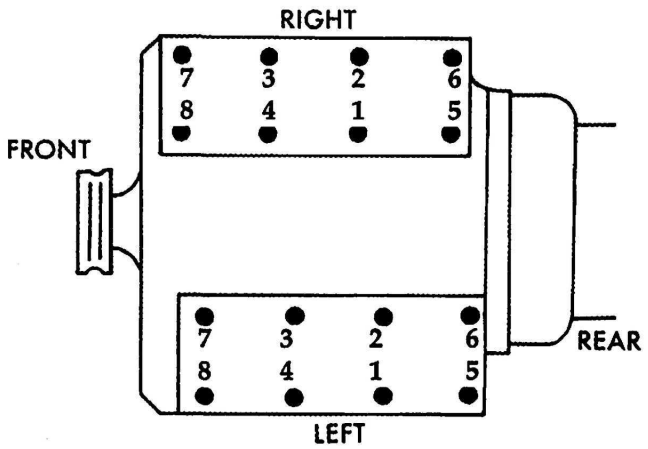
- Install the rocker arm shaft. Note that the pins in the bottom of the front and rear pedestals index the assembly to the cylinder head. (FIG. 138)
- Remove the 3mm pin punches.
- Lightly oil the threads and install the cylinder head bolts.

CAUTION: *Once the engine has been installed in the vehicle, the cylinder head retightening procedure MUST be performed for engines built prior to # 89616. (see cylinder head retightening procedure section).*



(FIG. 138)

- Tighten the cylinder head bolts in the sequence as follows: (FIG. 139)



(FIG. 139)

USE THIS PROCEDURE ON ENGINES UP TO AND INCLUDING # 89615.

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

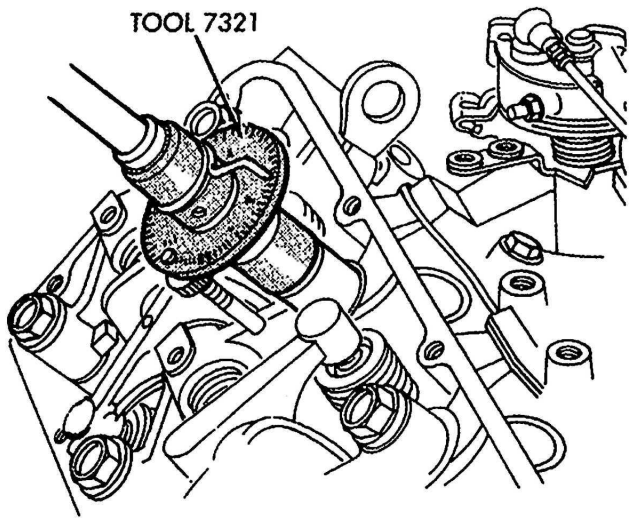
THE FOLLOWING PROCEDURE IS PERFORMED ON ALL BOLTS, ONE AT A TIME.

- Starting with bolt number one, loosen bolt completely.
- Tighten bolt number one to 15 ft-lbs (20 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 be tween the socket and the wrench. (FIG. 140)
- Angle tighten bolt number one to 106° (+/-2°).
- Repeat the above procedure for all remain ing bolts in the sequence. (FIG. 139)

USE THIS PROCEDURE ON ENGINES STARTING WITH # 89616

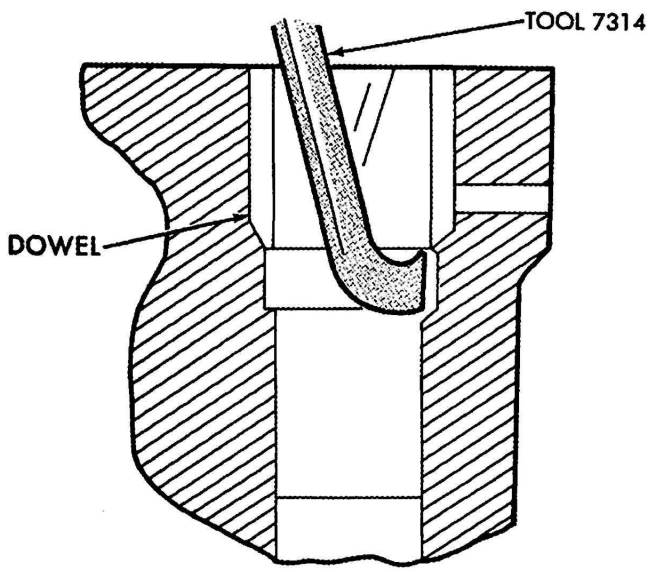
- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque. (FIG. 139)

- Starting with bolt number one, loosen all bolts completely.
- Starting with bolt number one, tighten all bolts to 30 ft-lbs (40 N.m) torque in thesequence shown.
- Install the graduated disc tool # 7321 between the socket and the wrench. (FIG. 140)



(FIG. 140)

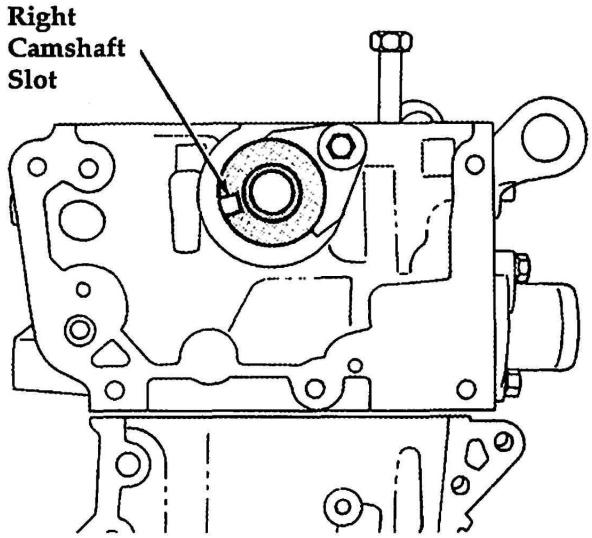
- Angle tighten bolt number one to 180° (+ 0, - 20) and repeat the procedure for all bolts in the sequence.
- Turn the engine on the stand until the right bank points up.
- Pull the cylinder head dowels up using dowel extractor tool # 7314. (FIG. 141)



(FIG. 141)

- Install 3mm pin punches into the holes in the block below the locating dowel. Push the dowels down until they contact the pin punches.

- Remove the cylinder liner clamps from the right cylinder head.
- Install dry, a new cylinder head gasket to the right cylinder bank.
- Position the right cylinder head over the new head gasket.
- Turn the right camshaft until the slot in the front is positioned as shown. (FIG. 142)



(FIG. 142)

- Install the rocker arm shaft. Note that the pins in the bottom of the front and rear ped estals index the assembly to the cylinder head. (FIG. 143)

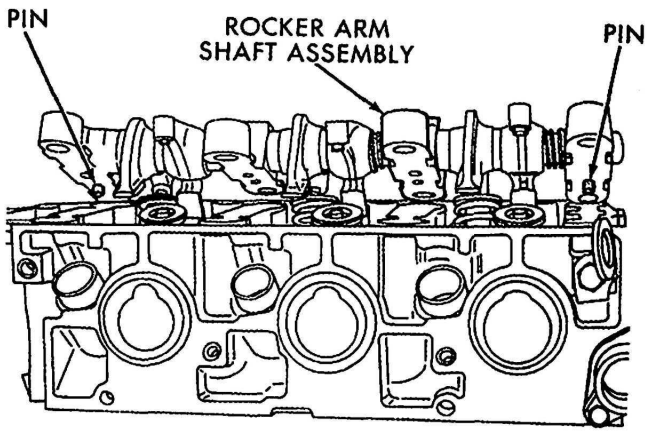
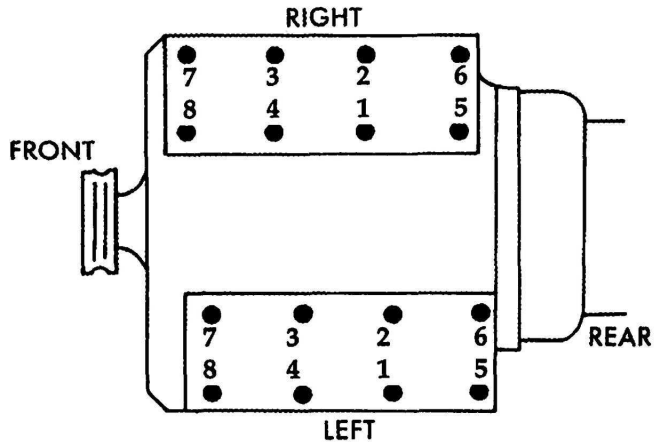


FIG. 143)

- Remove the 3mm pin punches.
- Lightly oil the threads and install the cylin der head bolts.
- Tighten the right hand cylinder head bolts in the sequence as follows. (FIG. 144)



(FIG. 144)

USE THIS PROCEDURE ON ENGINES UP TO AND INCLUDING # 89615.

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

THE FOLLOWING PROCEDURE IS PER-FORMED ON ALL BOLTS, ONE AT A TIME.

- Starting with bolt number one, loosen bolt completely.
- Tighten bolt number one to 15 ft-lbs (20 N.m) torque in the sequence shown.
- Install the graduated disc tool # 7321 be tween the socket and the wrench.
- Angle tighten bolt number one to 106° (+/-2°).
- Repeat the above procedure for all remain ing bolts in the sequence.

USE THIS PROCEDURE ON ENGINES STARTING WITH # 89616

- Starting with the number one bolt in the sequence, pre-tighten all bolts to 44 ft-lbs (60 N.m) torque.

- Starting with bolt number one, loosen all bolts completely.
- Starting with bolt number one, tighten all bolts to 30 ft-lbs (40 N.m) torque in these-quence shown.
- Install the graduated disc tool # 7321 be-tween the socket and the wrench.
- Angle tighten bolt number one to 180° (+ 0, - 20) and repeat the procedure for all bolts in the sequence.

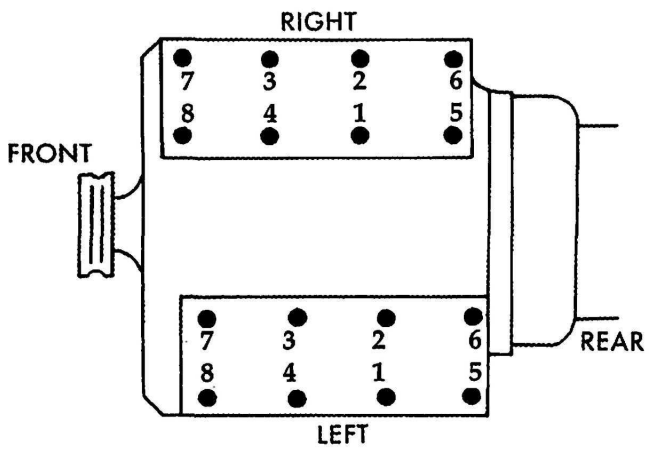
CYLINDER HEAD RETIGHTENING

Procedure

This procedure MUST be performed after a cylinder head has been removed and either replaced or installed (on engines built proir to engine number 89616).

NOTE: *This procedure does not have to be performed when installing a complete replacement engine.*

- With the engine installed in the vehicle, start and run the engine for 15 minutes (without a load) at 1800 to 2000 Rpm. Turn the engine off.
- Let the engine cool down for at least six hours.
- Remove the valve cover(s).
- Use the graduated disc tool # 7321 to angle tighten all cylinder head bolts an additional 45° in the tightening sequence. (FIG. 145)



(FIG. 145)

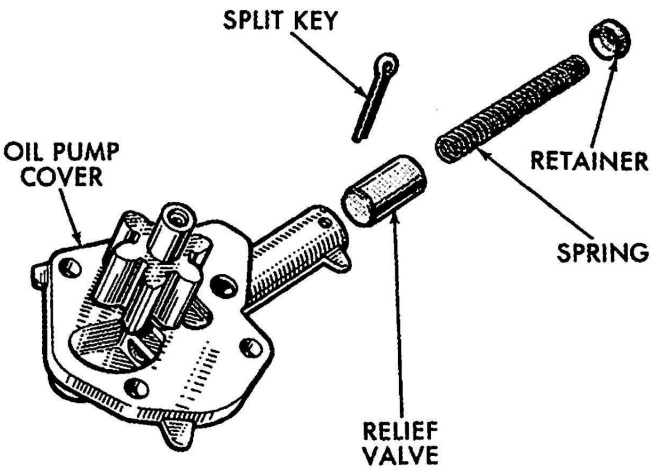
- Use a torque wrench to verify that each bolt has at least 52 ft-lbs (70 N.m) torque.

OIL PUMP

Installation

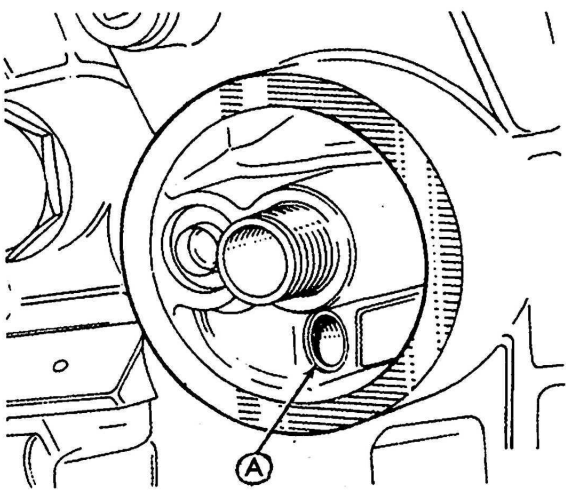
NOTE: *When installing the relief valve, the open end must face the spring.*

- Coat with clean engine oil and install the relief valve, spring, and retainer into the oil pump cover.
- Install the cotter pin. (FIG. 146)



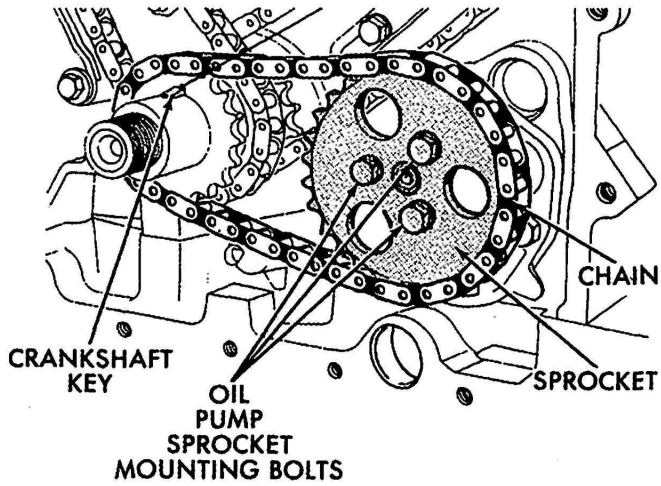
(FIG. 146)

- Lubricate the driven gear idler shaft with clean engine oil.
- Install the driven gear over the idler shaft.
- Install the oil pump cover. Tighten the bolts to 9 ft-lbs (12 N.m) torque.
- Prime the oil pump by squirting oil through the hole (A) below the oil filter connector. (FIG. 147)



(FIG. 147)

- Fill the oil filter with clean engine oil and install it on the engine.
- After the timing chains have been installed, install oil pump sprocket and chain. Coat the threads of sprocket mounting bolts with Loctite 262 and tighten the bolts to 48 in-lbs (6 N.m) torque. (FI. 148)



(FIG. 148)

TIMING CHAINS/TENSIONERS/ SPROCKETS

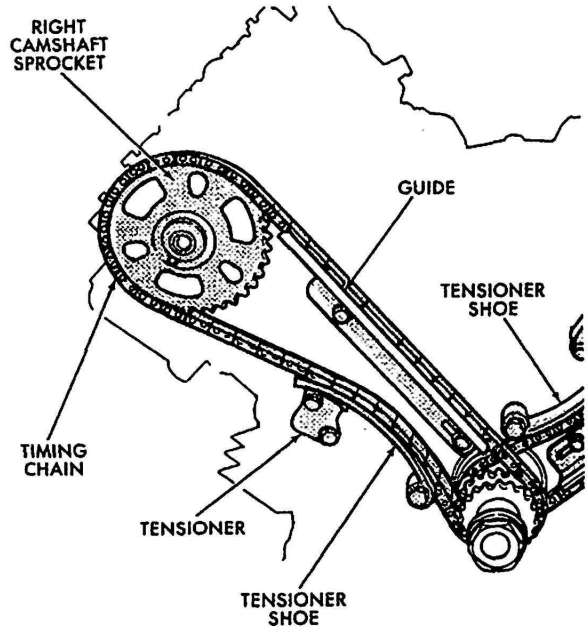
Installation

The timing chains are identical. New chains can be used on either camshaft sprocket. Used chains MUST be installed on the same side they were removed from.

The camshaft sprockets are not identical. The right camshaft sprocket has a spacer attached to it. the left camshaft sprocket does not have a spacer. (FIG. 149)

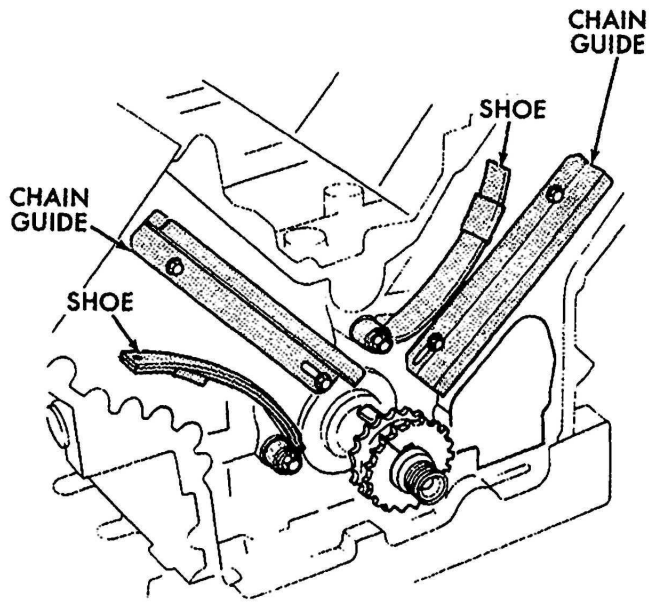
The timing chain tensioners, shoes and guides are identical and when NEW, can be used on either timing chain. Used tensioners, shoes and guides MUST be installed on the same side they were removed from.

NOTE: *When installing the timing chains and sprockets, the left bank of the engine must be timed first.*



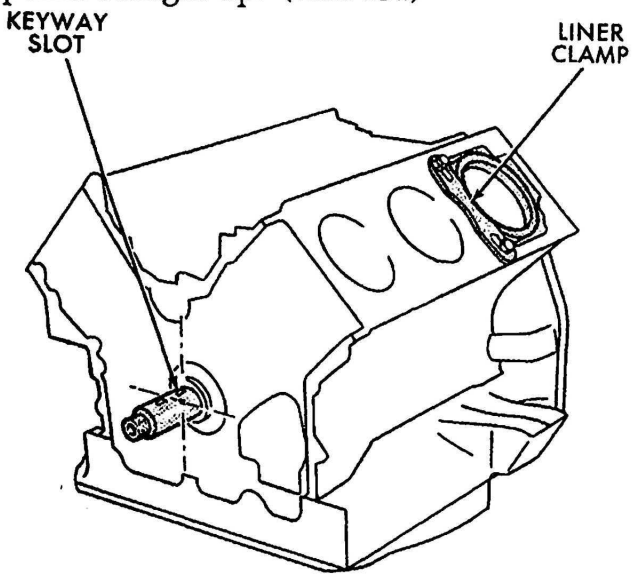
(FIG. 149)

- Install the chain guides. Tighten the bolts to 48 in-lbs (6 N.m) torque. (FIG. 150)
- Install the tensioner shoes. Tighten the bolts to 9 ft-lbs (12 N.m) torque. (FIG. 150)



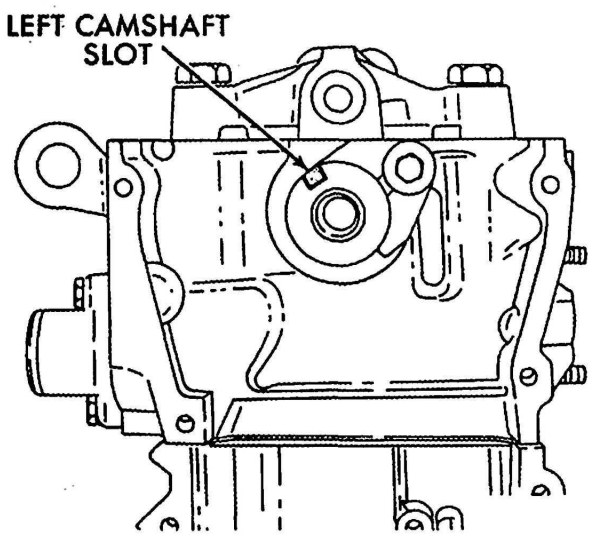
(FIG. 150)

- Turn the crankshaft so that the keyway points straight up. (FIG. 151)



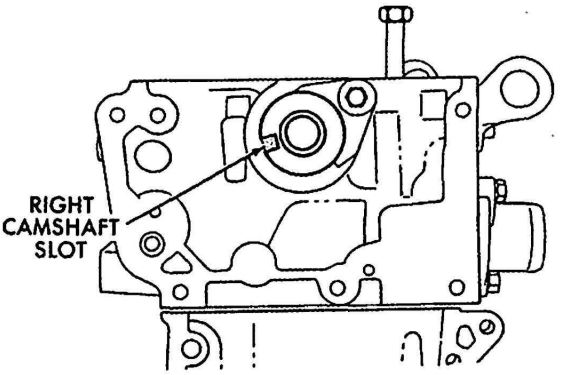
(FIG. 151)

- Turn the left camshaft until the slot in the front is positioned as shown (approx. 11 O'clock position). (FIG. 152)



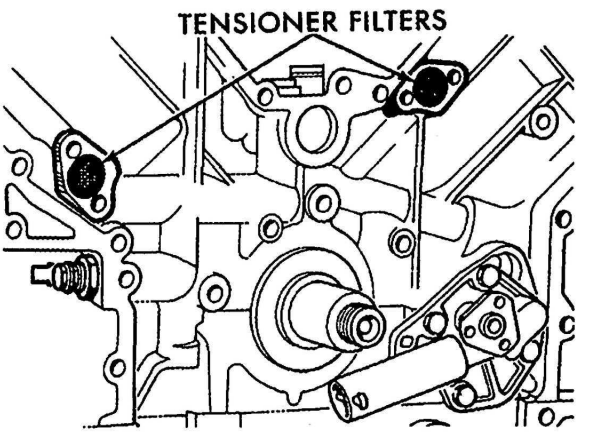
(FIG. 152)

- Turn the right camshaft until the slot in the front is positioned as shown (Between ap prox. 8 and 9 O'clock position). (FIG. 153)



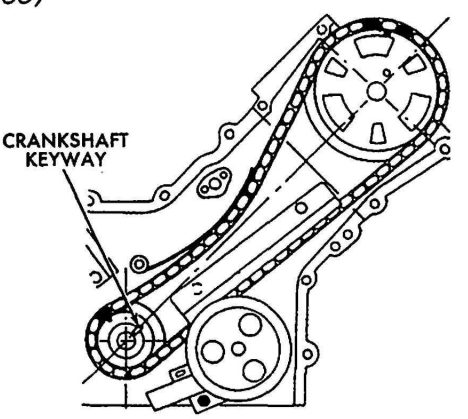
(FIG. 153)

- Install the tensioner filters. (FIG. 154)



(FIG. 154)

- Turn the crankshaft in a clockwise direction until the crankshaft keyway is aligned with the centerline of the left cylinder bank. (FIG. 155)

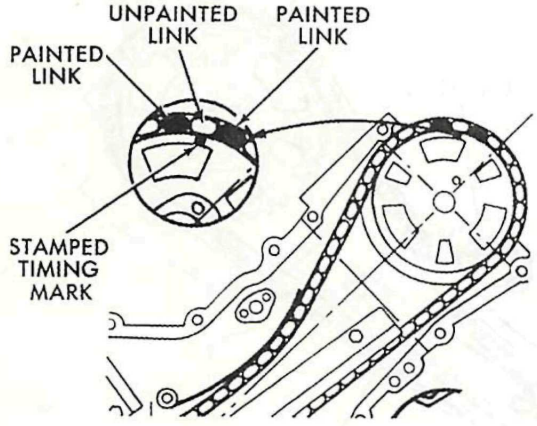


(FIG. 155)

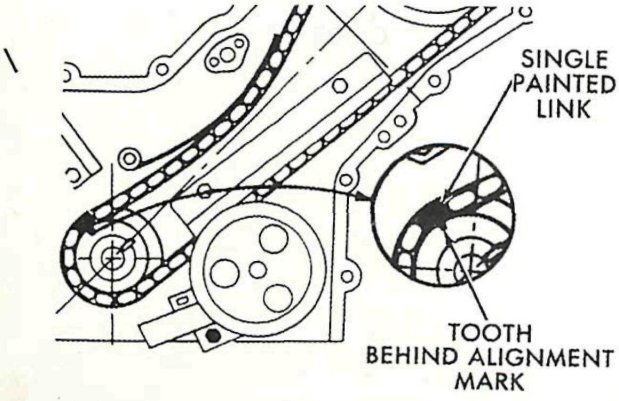
Installation - Left Timing Chain

NOTE: *The crankshaft has three separate sprockets. One is for the left timing chain, one is for the right timing chain, and one is for the oil pump chain. The timing mark is located on the middle (or second) sprocket which is for the RIGHT timing chain. When installing the left timing chain, position the single painted link of the LEFT timing chain onto the tooth to the rear sprocket that is directly behind the tooth of the middle sprocket that has the timing mark.*

The left camshaft sprocket does not have a built in spacer. Install the left timing chain so that the unpainted link that is between two painted links is aligned with the stamped timing mark on the left camshaft sprocket. The single painted link on the bottom of the chain must be aligned with the tooth of the rear crankshaft sprocket which is directly behind the tooth in the middle sprocket with the timing mark. (FIG. 156 & 157)

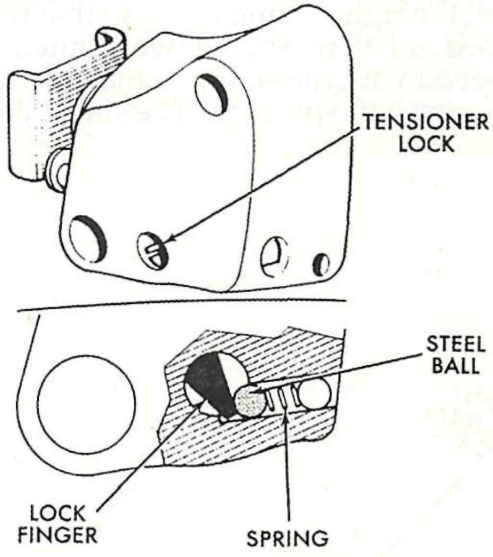


(FIG. 156)



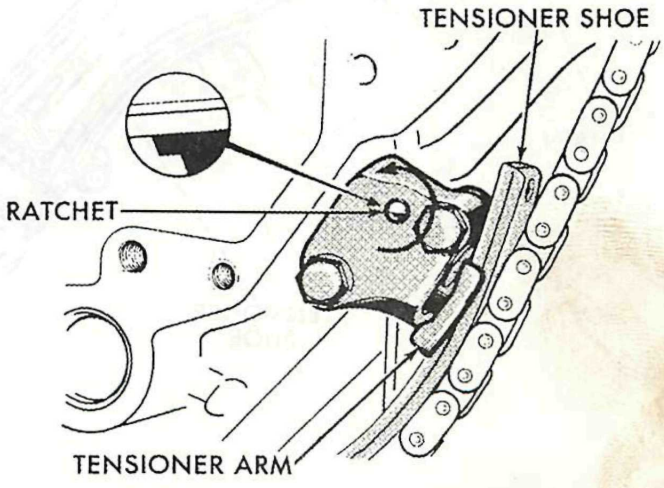
(FIG. 157)

NOTE: *Timing chain tensioner lock should not be removed. The lock is held in place by a spring that pushes a steel ball against a lock finger. If the lock is removed accidentally, replace the tensioner assembly because there is no way of checking the position of the lock finger in relation to the steel ball.* (FIG. 159)



(FIG. 159)

To install the left timing chain tensioner use a thin bladed screwdriver to turn the ratchet counterclockwise. Then push the tensioner arm over the filter and tensioner shoe into the arm. (FIG. 160)

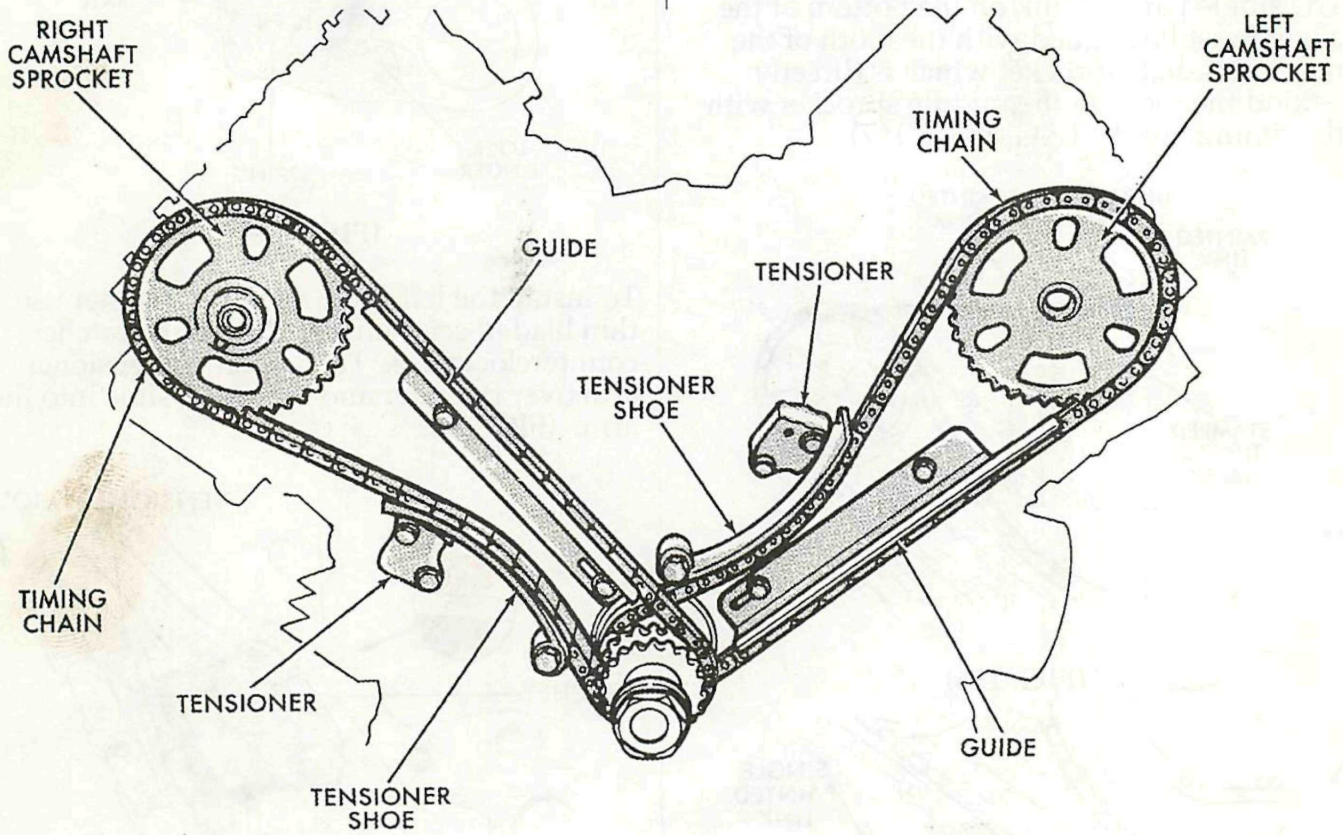


(FIG. 160)

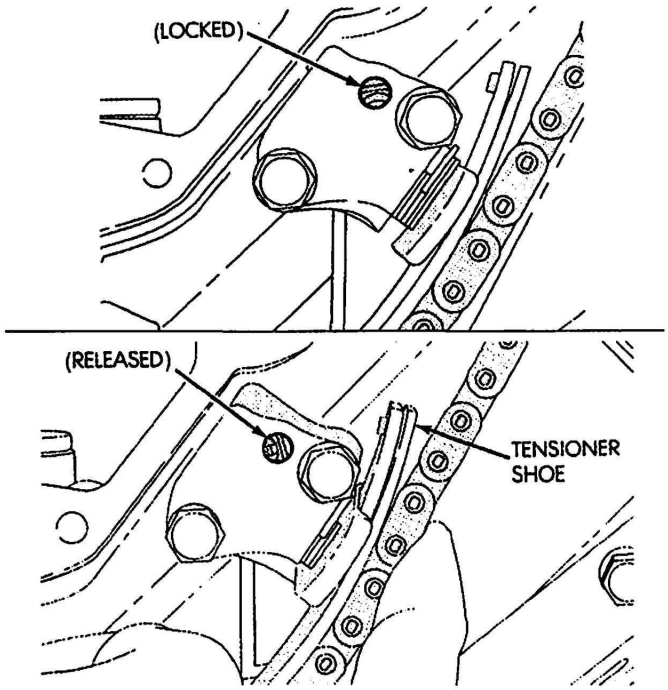
- Tighten the mounting bolts to 48 in-lbs (6.3 N.m) torque.

Installation - Right Timing Chain

- Rotate the crankshaft approximately 150° until the timing mark on the crankshaft middle sprocket is aligned with the lower oil pump cover mounting bolt.
- The right sprocket has a built-in spacer. Install the right timing chain so that the unpainted link between the two painted links is aligned with the stamped mark on the right camshaft sprocket. The single painted link on the bottom of the timing chain should be aligned with the timing mark on the middle sprocket. (FIG. 161)
- Install the right timing chain tensioner in the same manner that the left timing chain tensioner was installed. (FIG. 162)
- Install the right camshaft sprocket bolt and tighten to 59 ft-lbs (80 N.m) torque.
- Push both tensioner shoes in to release the ratchet of the tensioner from the locked out position and then let the shoes out.



(FIG. 161)

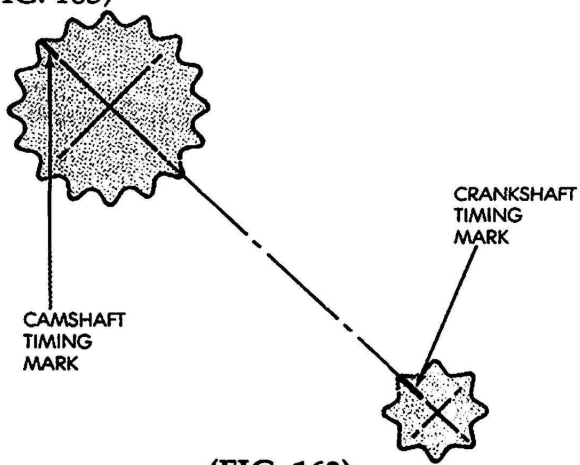


(FIG. 162)

VALVE TIMING CHECK

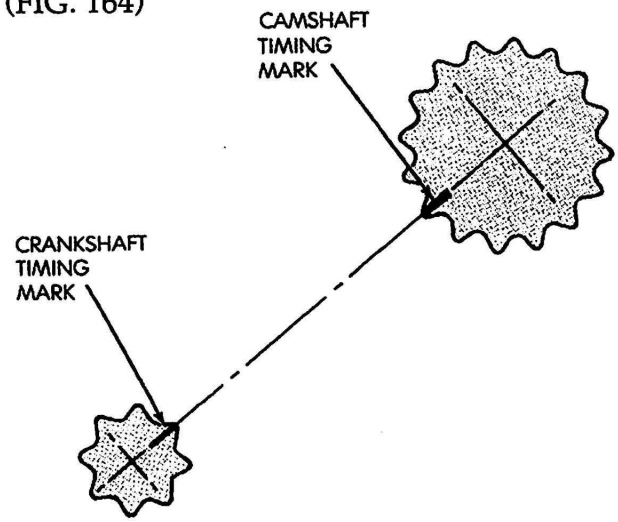
NOTE: *Once the crankshaft is rotated, the paint marks on the timing chains will not align with the marks on the sprockets. When checking valve timing, it is the position to the timing marks in relation to one another that is checked, NOT the position of the paint marks on the chains.*

- First rotate the crankshaft 180°. Check that the timing mark on the right camshaft sprocket and the timing mark on the crankshaft sprocket are aligned as shown. (FIG. 163)



(FIG. 163)

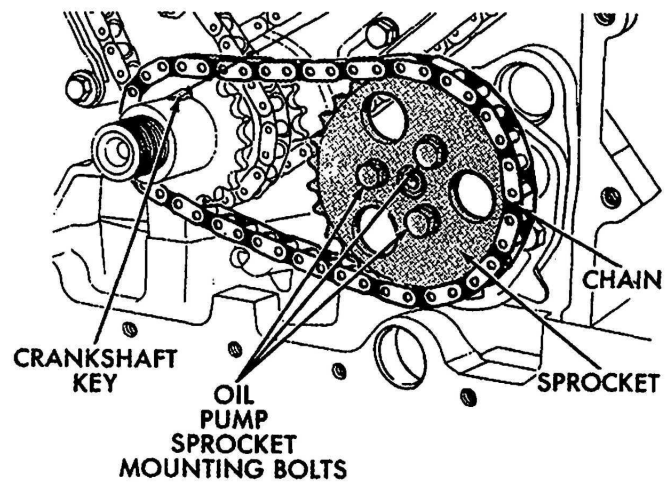
- Now rotate the crankshaft another 90°. The timing mark on the left camshaft sprocket and the timing mark on the crankshaft sprocket should be aligned as shown. (FIG. 164)



(FIG. 164)

Installation - Oil Pump Chain

- Install oil pump sprocket and chain.
- Apply Loctite 271 to the sprocket bolts.
- tighten bolts to 48 in-lbs (6.3 N.m) torque. (FIG. 165)



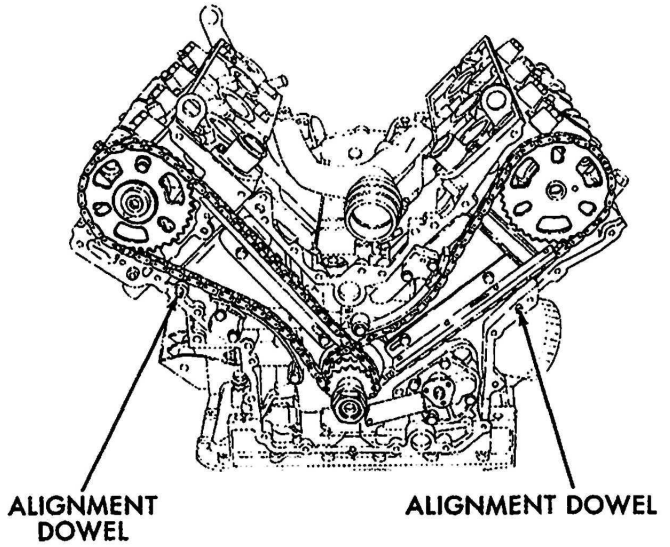
(FIG. 165

TIMING COVER/CRANKSHAFT PULLEY

Installation

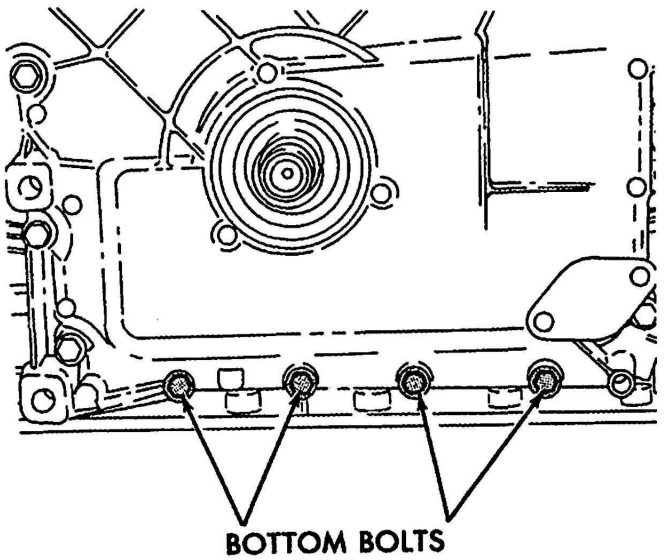
- Rotate the crankshaft so that the keyway points up. This will prevent the key from falling into the oil pan.

- Put a small amount of RTV sealer at the mating lines of the cylinder head and block and the lower casing block.
- Install the timing cover with a new gasket over the alignment dowels. (FIG. 166)



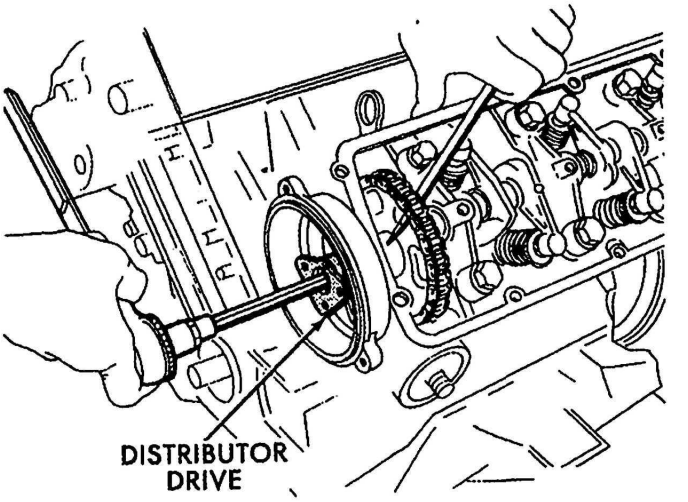
(FIG. 166)

- Install the mounting bolts. On the four bottom bolts, apply Loctite 271 to the bolt threads. Tighten all front cover bolts to 9 ft-lbs (12.5 N.m) torque. (FIG. 167)



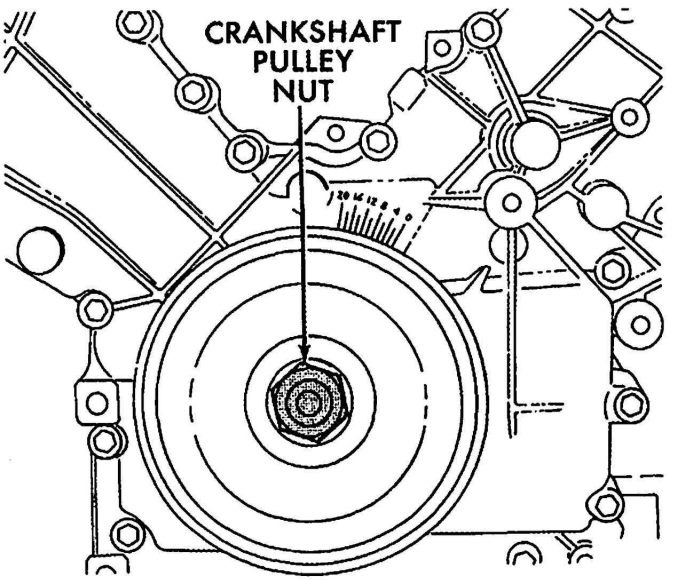
(FIG. 167)

- Install the distributor drive/left camshaft sprocket mounting bolt. Tighten the bolt to 59 ft-lbs (80 N.m) torque. (FIG. 168)



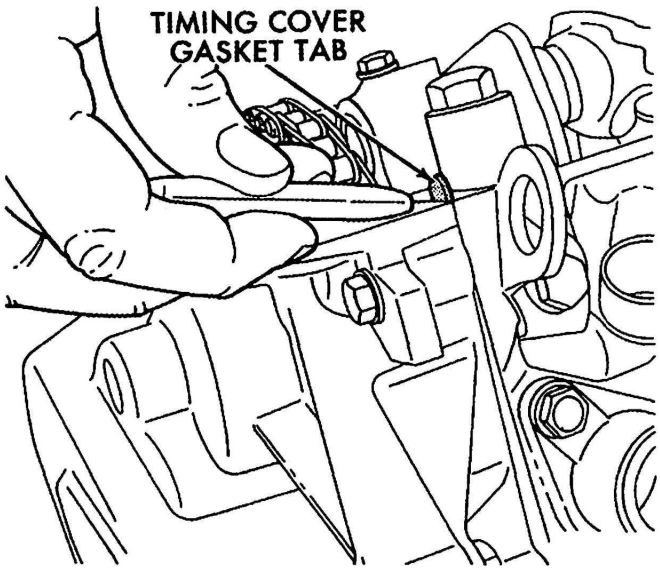
(FIG. 168)

- Install the crankshaft pulley. Apply Loctite 271 to the threads of the pulley nut. Tighten the nut to 133 ft-lbs (180 N.m) torque. (FIG. 169)



(FIG. 169)

- Cut the timing cover gasket tabs flush with the head. The tabs protrude above the front cover and cylinder head. (FIG. 170)



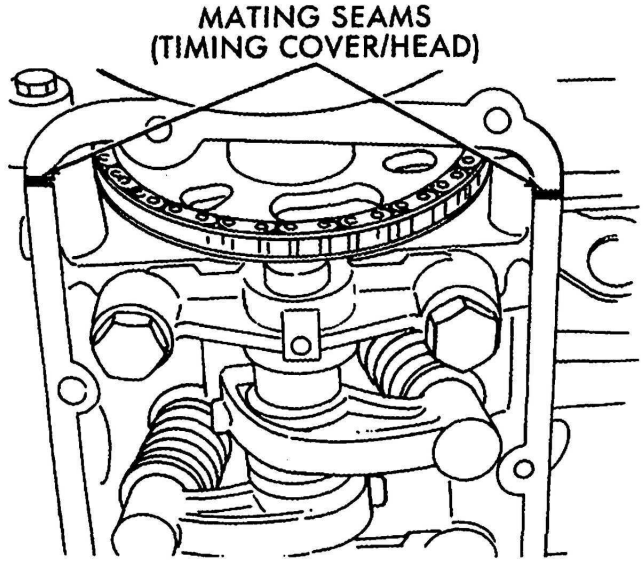
(FIG. 170)

CYLINDER HEAD COVERS

Installation

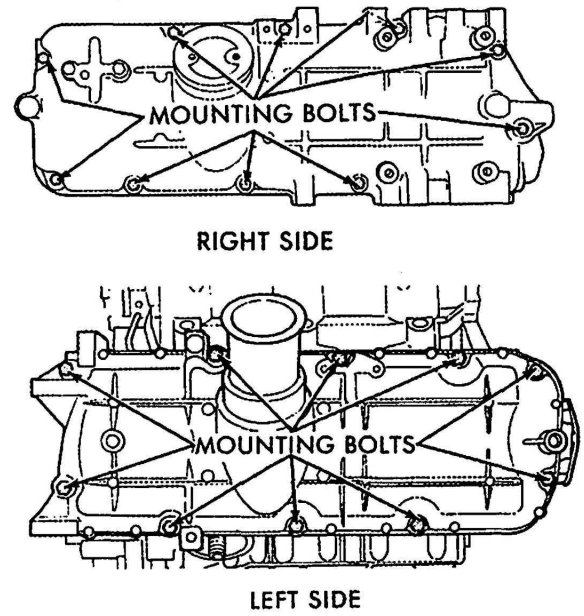
NOTE: *The right and left cylinder head gaskets are not identical.*

- Prior to installing a new cylinder head cover gasket, apply a dab a RTV sealer at the timing cover to cylinder head mating seams. (FIG. 171)



(FIG. 171)

- Use new gaskets and install the right cylinder head and the left cylinder head cover.
- Tighten the mounting bolts to 9 ft-lbs (12.5 N.m) torque. (FIG. 172)

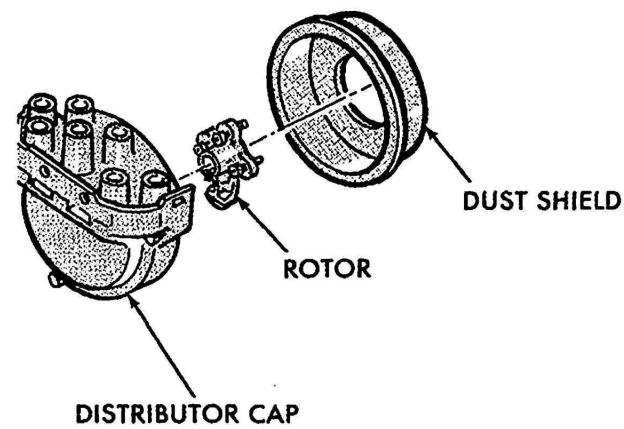


(FIG. 172)

DISTRIBUTOR CAP/ROTOR/DUST COVER

Installation

- Install the dust cover into the distributor housing.
- Install rotor. (FIG. 173)



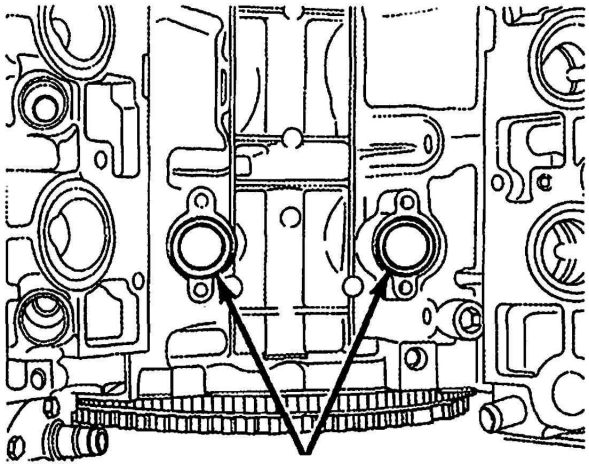
(FIG. 173)

- Tighten the mounting screws to 26 in-lbs (3 N.m) torque.
- Install the distributor cap.
- Tighten the mounting screws to 72 in-lbs (9 N.m) torque.

WATER PUMP

Installation

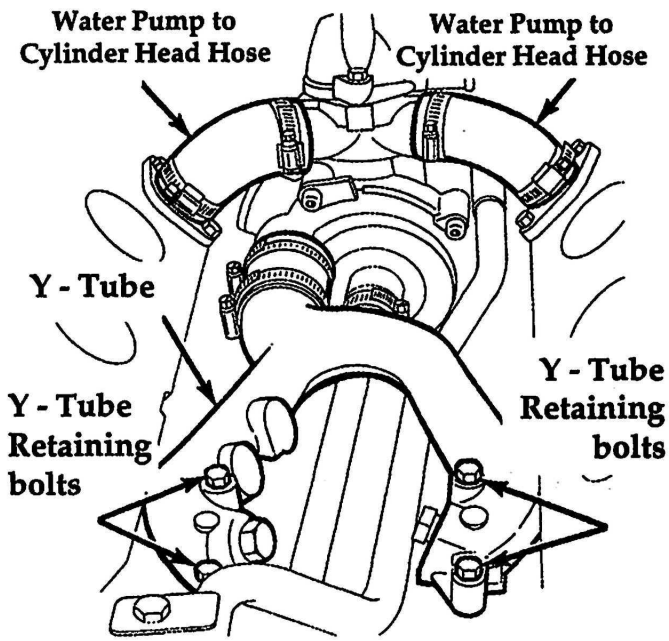
- Install two new "Y" tube O-ring seals into the top of the cylinder block. (FIG. 174)



Y - Tube O - rings

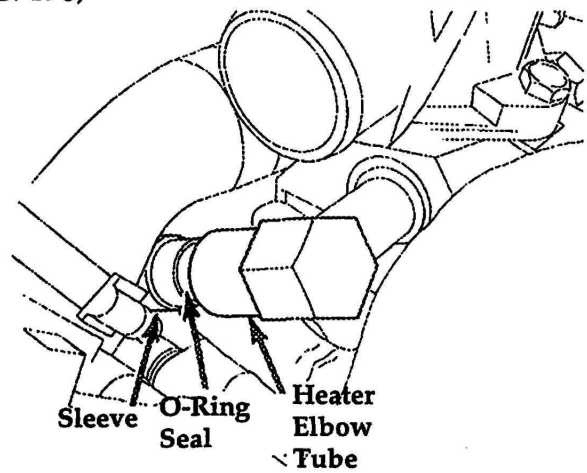
(FIG. 174)

- Install "Y" tube and water pump as an assembly.
- Tighten the "Y" tube bolts to 9 ft-lbs (12.5 N.m) torque. (FIG. 175)
- Tighten the water pump mounting bolts to 13 ft-lbs (17.5 N.m) torque.



(FIG. 175)

NOTE: *Heater tube elbow connector has O-ring seals inside to seal the heater tube. To ensure correct sealing of the heater tube, the tube must be first pushed into the elbow connector until it stops. Then the locking sleeve is pushed in until it stops.* (FIG. 176)



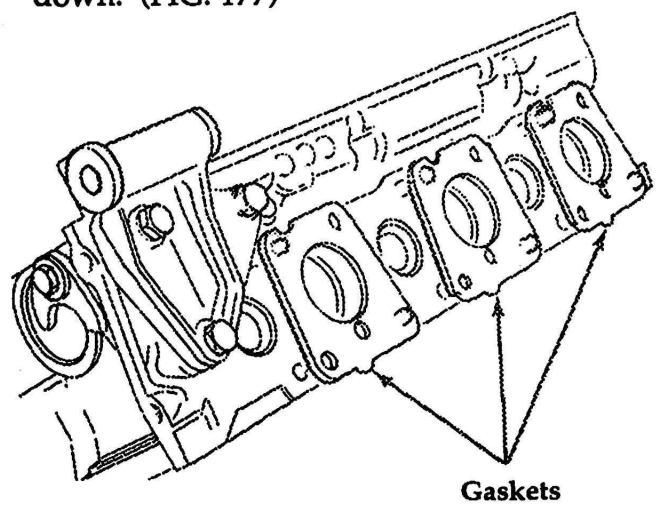
(FIG. 176)

- Tighten all hose clamps.

EXHAUST MANIFOLD

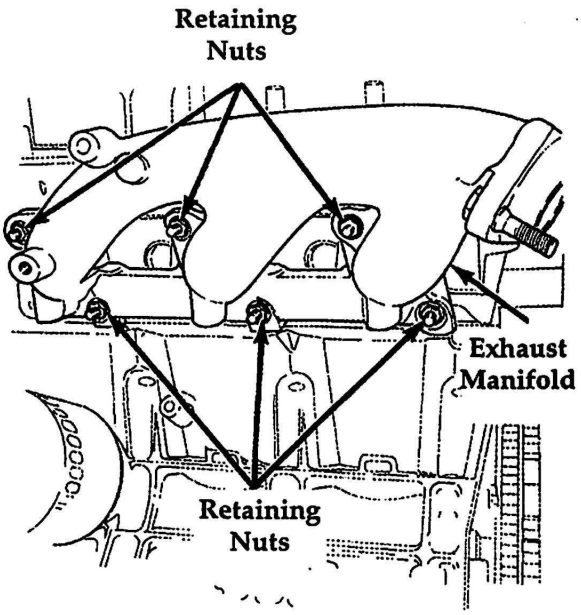
Installation

- Remove the engine from the stand.
- Install the gasket with the tabs pointing down. (FIG. 177)



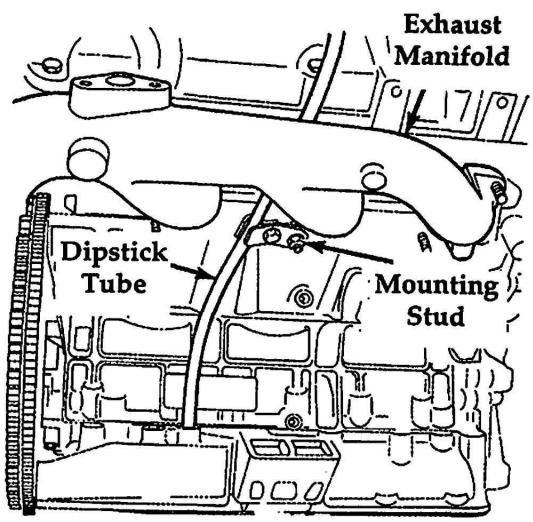
(FIG. 178)

- Install the left exhaust manifold.
- Tighten the mounting nuts to 13 ft-lbs (18 N.m) torque. (FIG. 179)



(FIG. 179)

- Install the right exhaust manifold.
- Install the dipstick tube with a coating of Loctite 271 on the end of the tube that presses into the lower casing. (FIG. 180)
- Tighten the mounting nuts to 13 ft-lbs (18 N.m) torque.
- Tighten the dipstick clamp nut to 13 ft-lbs (18 N.m) torque. (FIG. 180)

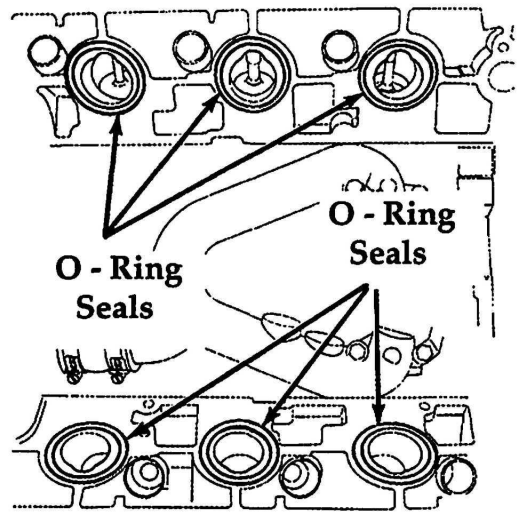


(FIG. 180)

INTAKE MANIFOLD

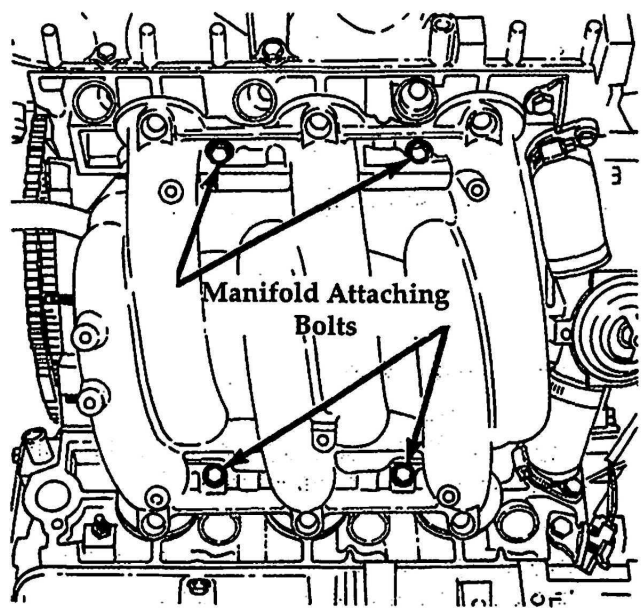
Installation

- Install six new O-ring seals into the grooves around the intake ports of the cylinder heads. (FIG. 181)



(FIG. 181)

- Install the intake manifold.
- Tighten the mounting bolts to 9 ft-lbs (12.5 N.m) torque. (FIG. 182)

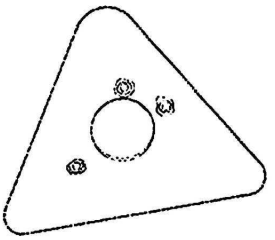


(FIG. 182)

SPECIAL TOOLS

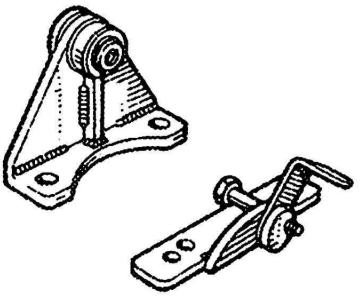
Tool # 6140

Alignment Plate
(Lower Casing to Block)



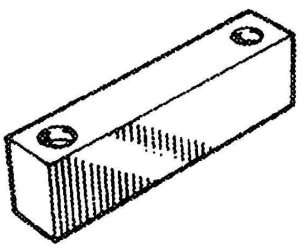
Tool # 7317

Camshaft Sprocket
Supports



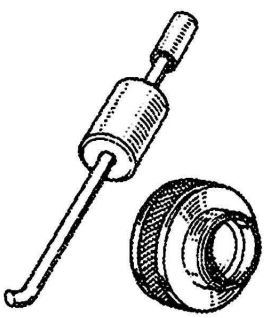
Tool # 6017

Crankshaft Main
Bearing Clamps



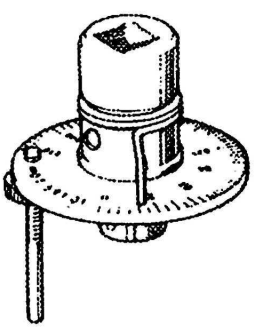
Tool # 7314

Cylinder Head
Dowel Extractor



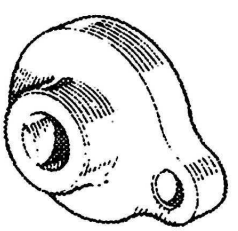
Tool # 7321

Angular Wrench



Tool # 6072

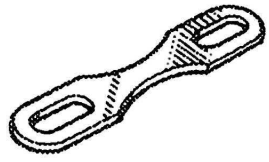
Crankshaft Turning Tool



SPECIAL TOOLS

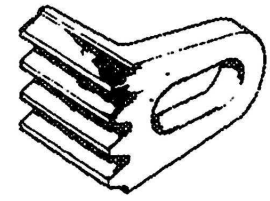
Tool # 7315

Cylinder Liner Clamps



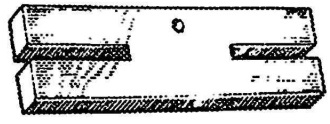
Tool # 7311

Flywheel Lock



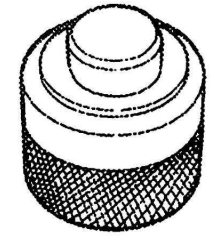
Tool # 6296

Dial Indicator Support



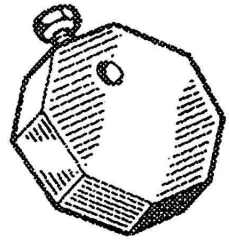
Tool# 6126

Oil Seal Installer (Distributor Driver)



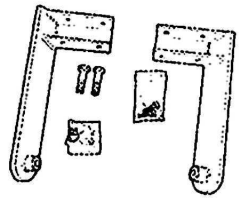
Tool # 6395

Linear Protrusion Thrust Block



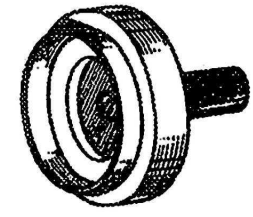
Tool # 6183

Engine Support Stand



Tool # 7224 & Tool # 6482

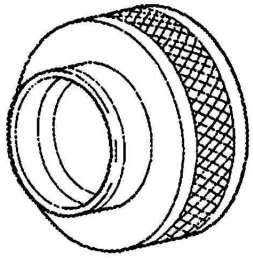
Oil Seal Installer (Rear Of Crankshaft)



SPECIAL TOOLS

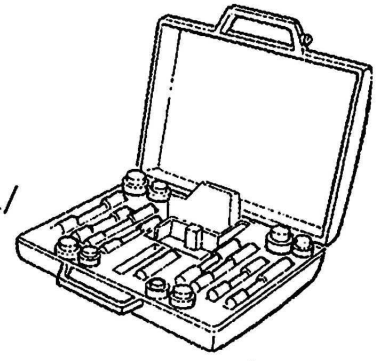
Tool # 6077

Oil Seal Installer
(Front Of Crankshaft)



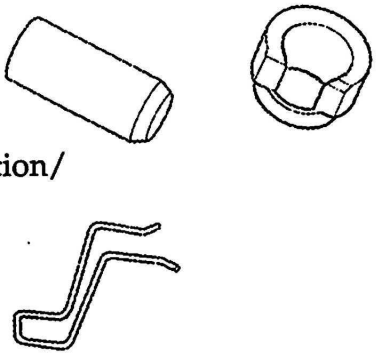
Tool # 7305

Piston Pin Removal/
Installation Kit



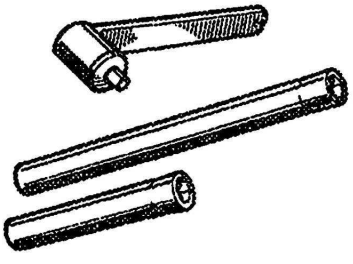
Tool # 6137

Piston Pin Installation/
Removal Tools



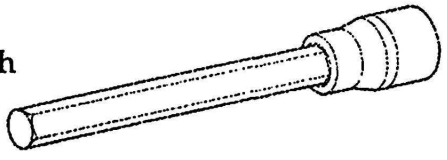
Tool # 7352

Spark Plug Wrench
(Limited Torque)



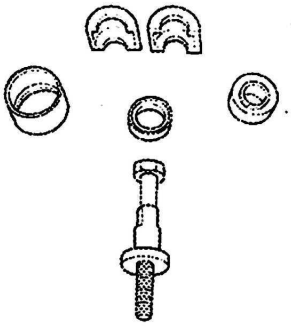
Tool # 7399

Socket Wrench
(10mm Hex)



Tool # 6160

Water Pump Pulley
Puller



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